T. O. 2R-R1820-3
(Formerly 02A-35GC-3)

HANDBOOK
OVERHAUL INSTRUCTIONS

MODELS
R-1820-40, -40B, -54, -60, -65, -71, -73, -87, -97
AIRCRAFT ENGINES
(CURTISS-WRIGHT)

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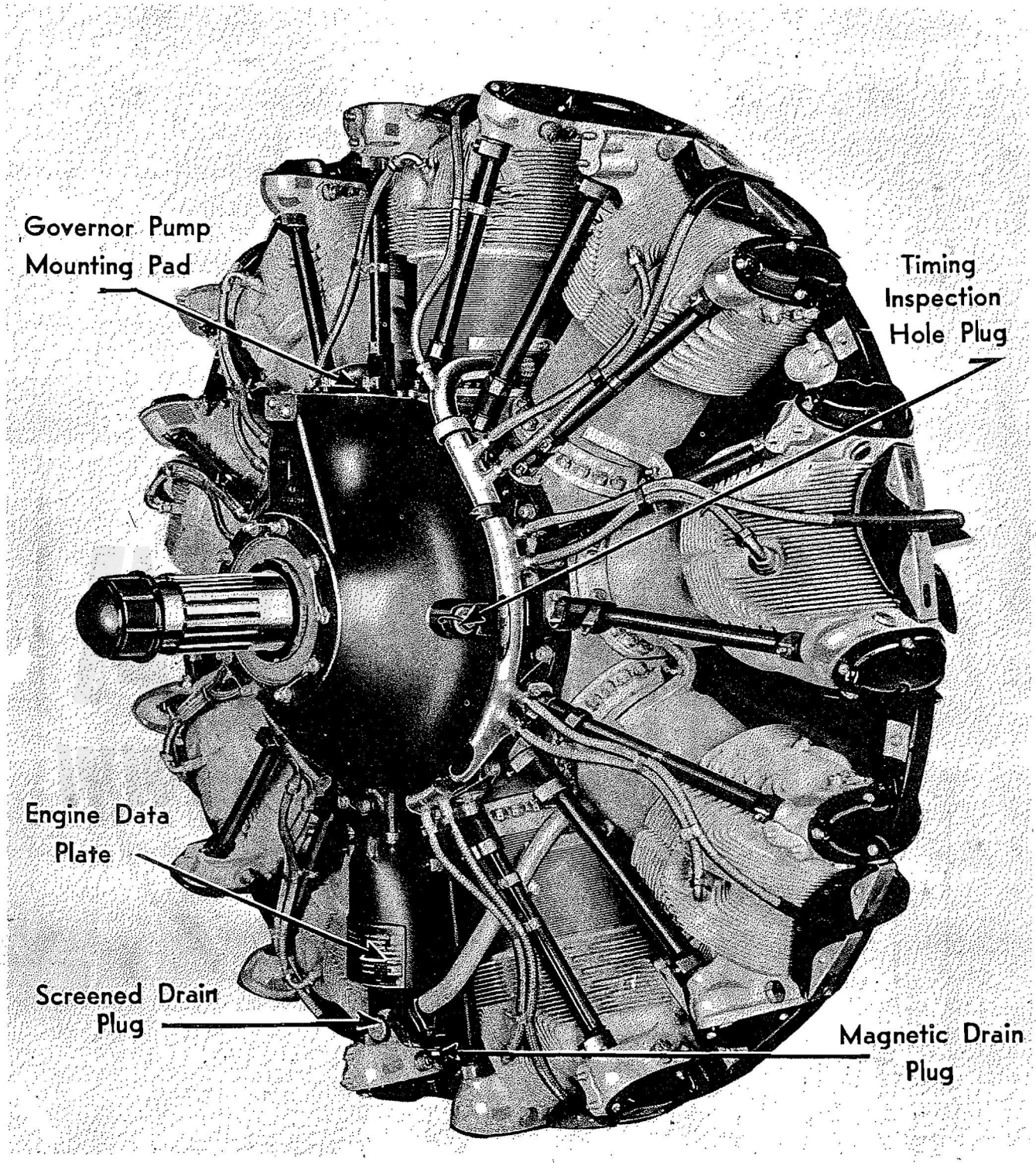

Figure 1—Three-Quarter Left Front View

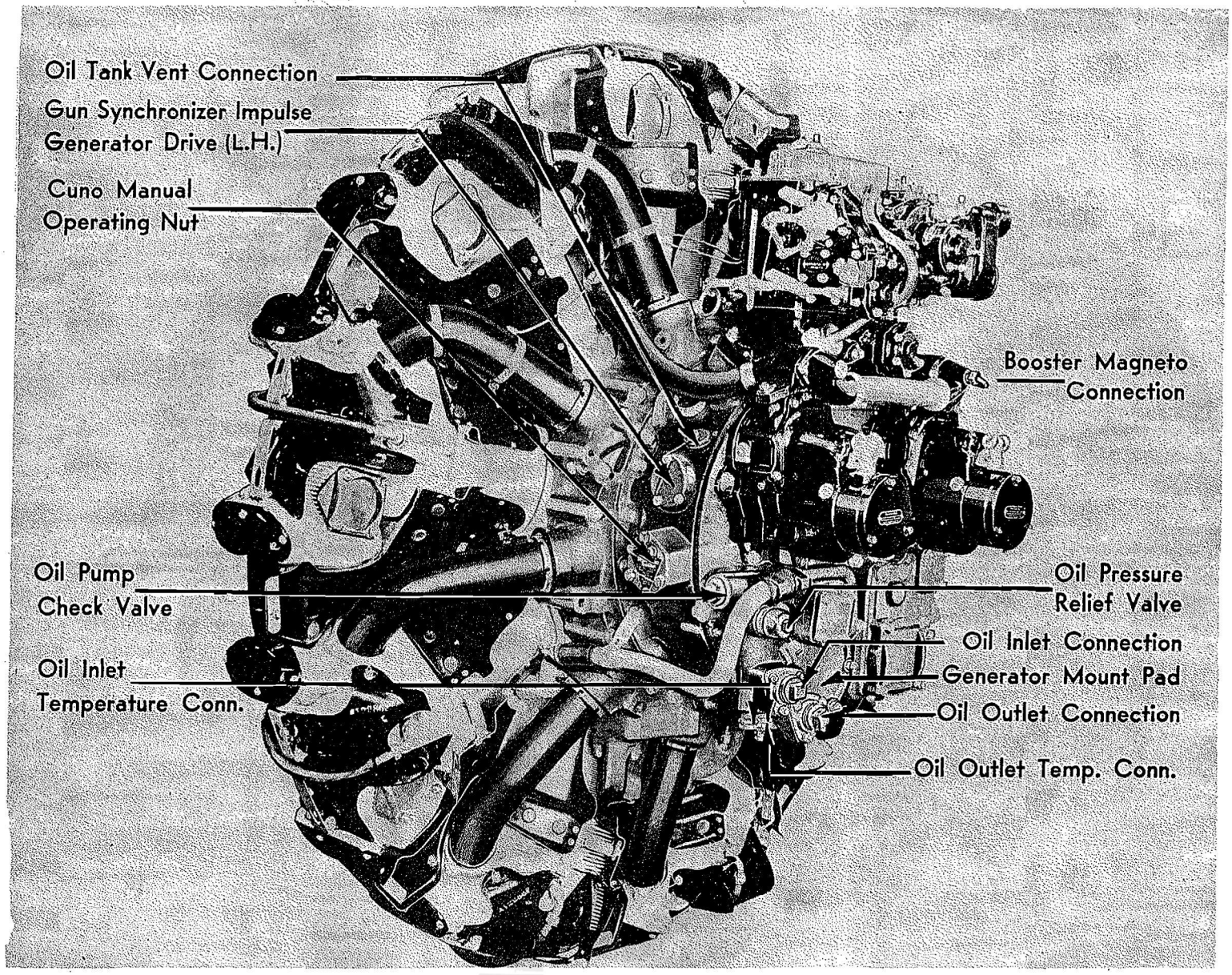

Figure 2—Three-Quarter Left Rear View

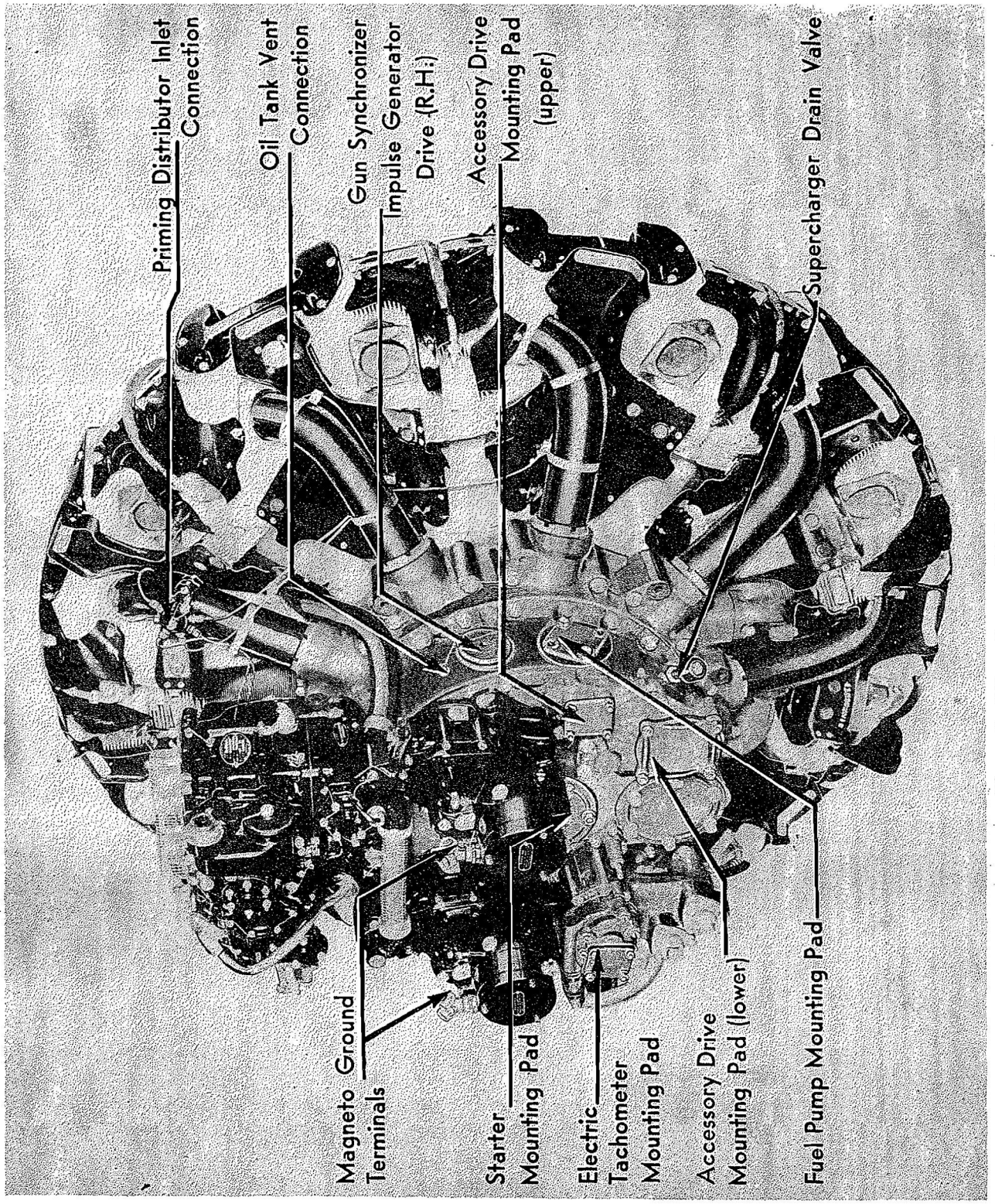

Figure 3—Three-Quarter Right Rear View

SECTION I
INTRODUCTION

1. This publication comprises the overhaul instructions for the models R-1820-40, -40B, -54, -60, -65, -71, -73, -87, and -97 engines designed by Wright Aeronautical Corporation, Paterson, N. J.

2. Frequent reference is made to the Table of Limits, Section XII. This table shall be regarded as the indispensable guide throughout the operations which involve measurement or the use of gages.

3. In this publication, the following definitions will be used:

a. The "front" of the engine refers to the propeller end.

b. The "rear" of the engine refers to the anti-propeller end.

c. The "right" and "left" sides of the engine refer to the viewpoint of an observer facing the anti-propeller end of the engine.

d. The rotation of the crankshaft and propeller is clockwise as viewed from the rear of the engine.

e. The terms "clockwise" and "counterclockwise," in respect to accessory drive rotation, refer to the viewpoint of an observer facing the accessory drive.

f. The cylinders are numbered consecutively in the direction of rotation of the crankshaft, beginning with the top cylinder which is designated as Cylinder No. 1.

g. The "horizontal position" refers to the position of the engine in level flight.

h. Specification numbers as listed in this Handbook are basic numbers and will be interpreted to include all revisions and amendments thereto.

SECTION II
GENERAL DESCRIPTION

1. DIFFERENCES BETWEEN MODELS.

a. The model R-1820-40, -40B, -60, -65, -71, -73, -87, and -97 engines are basically the same in design and construction. However, there are several differences between these models which affect the installation, operation, servicing, and overhaul of the engines. The R-1820-54 engine differs from all the other engines in that it is a direct drive engine. These differences are shown in Table A.

TABLE A

	R-1820-40	*R-1820-40B*	*R-1820-54*	*R-1820-60*	*R-1820-65 and R-1820-97*	*R-1820-71*	*R-1820-73*	*R-1820-87*
Reduction Gear Ratio	3:2	3:2	Direct Drive	3:2	16:9	3:2	3:2	3:2
Gun Synchronizer to Crankshaft Speed Ratio	2:3	None	None	2:3	9:16	2:3	None	None
Impeller Drive	Roller or Plate Type Clutch	Roller Type Clutch	Roller Type Clutch	Roller Type Clutch	Single Speed	Single Speed	Single Speed	Roller Type Clutch
Turbo Supercharger	No	No	No	No	Yes	No	Yes	No
Bendix-Stromberg Injection Carburetor	PD-12H3	PD-12H3	PD-12H3	PD-12K4	PD-12H2	PD-12H3	PD-12H2	PD-12H3
Type of Breather (Army)				Crankshaft or Crankcase	Crankcase	Crankcase	Crankcase	Crankshaft
Type of Breather (Navy)	Crankshaft	Crankshaft	Crankcase	Crankshaft				
Oil Pump Check Valve (Army)	Some			Yes	Yes	Yes	Yes	Some
Oil Pump Check Valve (Navy)	Some	No	No	No				
Supercharger Drain Valve Type	Standard	Standard	Standard	Standard	Turbo	Standard	Turbo	Standard

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TABLE A (Cont)

	R-1820-40	R-1820-40B	R-1820-54	R-1820-60	R-1820-65 and R-1820-97	R-1820-71	R-1820-73	R-1820-87
Priming System	Five-point	One-point	Two-point	Two-point	Five-point	One-point	Five-point	Five-point
External Hydro Oil Line	Some	No	Yes	Yes	-65 No -97 Yes	No	No	No
Detachable Starter Coupling	12-Jaw	12-Jaw	12-Jaw	12-Jaw	3-Jaw	3-Jaw	3-Jaw	3-Jaw
Magneto Type	SF_9LN_4	SF_9LN_4	SF_9LD-1	SF_9LU_3	SF_9LU_3 Some -65 Engines Use SF_9LN_4	SF_9LN_4	SF_9LN_4	SF_9LN_4
External Oil Scavenge Line	Yes	Yes	Yes	Yes	-65 Some -97 Yes	Yes	No	Yes

b. Engines equipped with turbo superchargers require a special supercharger drain valve assembly.

c. The R-1820-97 engines incorporate an external hydro oil supply line leading from the left-hand gun synchronizer drive location on the supercharger rear housing to the low pressure governor oil supply passage in the crankcase front section. The installation of this line on former R-1820-65 engines and the necessary removal of the left-hand gun synchronizer drive substituting cover changed this model to the R-1820-97. In later R-1820-97 engines, this hydro oil supply line leads from the left edge of the starter pad to a connection on the crankcase front section adjacent to the intake valve tappet boss of cylinder No. 7.

2. CYLINDERS.

a. The cylinders are built up by shrinking threaded cast aluminum alloy heads on forged steel barrels. Form-fit, ground buttress type cylinder head attaching threads are used. The exhaust port boss faces toward the rear of the engine and is provided with four studs for attachment of the exhaust stacks. The intake port boss is located at the rear of the cylinder head and faces to the right and downward. Rubber packing is used between the intake pipe flange and the cylinder head to form a tight seal. Refer to Figure 4.

b. The valves are inclined to the center line of the cylinder at an angle permitting a hemispherical combustion chamber. Bronze valve guides and steel valve seats are shrunk into the cylinder head.

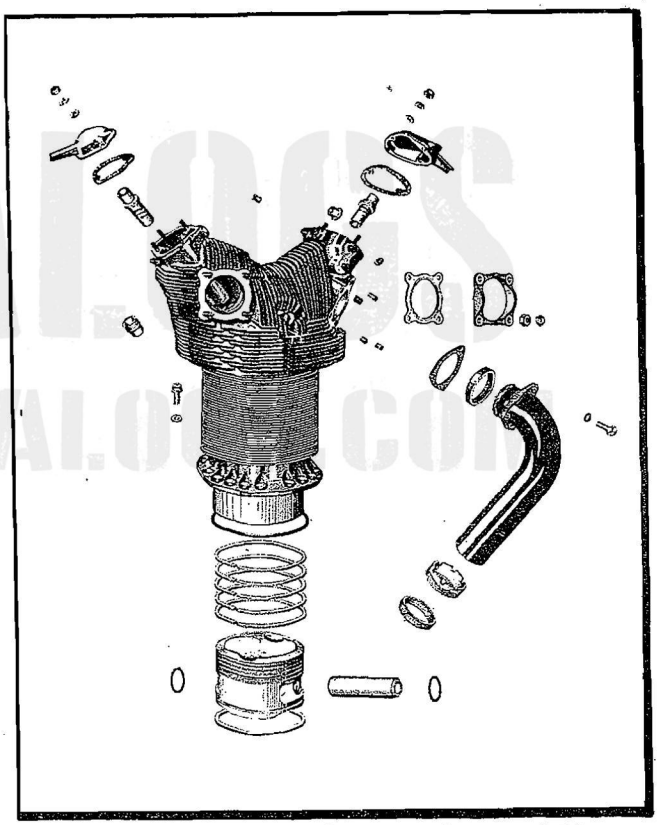

Figure 4—Cylinder, Intake Pipe, Piston and Piston Rings

c. Two bronze spark plug bushings are screwed and pinned in the front and rear of the cylinder head. The bushings, located just above the main horizontal cooling fins of the cylinder head, are symmetrical and at 90° to each other. Each bushing is surrounded by deep vertical cooling fins.

d. The intake and exhaust rocker boxes of each cylinder are provided with four studs for securing the rocker box covers. Bosses are cast integral with the cylinder at the front and rear of each rocker box and are equipped with studs for attachment of the engine cowling. Push rod housing connecting sleeves are screwed into the forward end of the rocker boxes forming oil-tight seals.

e. The cylinder barrel, with integral cooling fins, bolting flange, and threads to secure the cylinder head, is machined from a steel forging. The surface of the cylinder bore is nitrided to increase the life of the cylinder. Pressure type cylinder barrel and cylinder head air deflectors and air cooled type spark plugs are used. Refer to Figure 5. Twenty holes are provided in the bolting flange for attaching the cylinder assembly to the crankcase. Cap screws and spherical seat washers are used to bolt the cylinders to the steel crankcase.

f. A boss, located just forward of the intake pipe flange on each cylinder intake port, is drilled and tapped to receive either a priming line fitting or a plug.

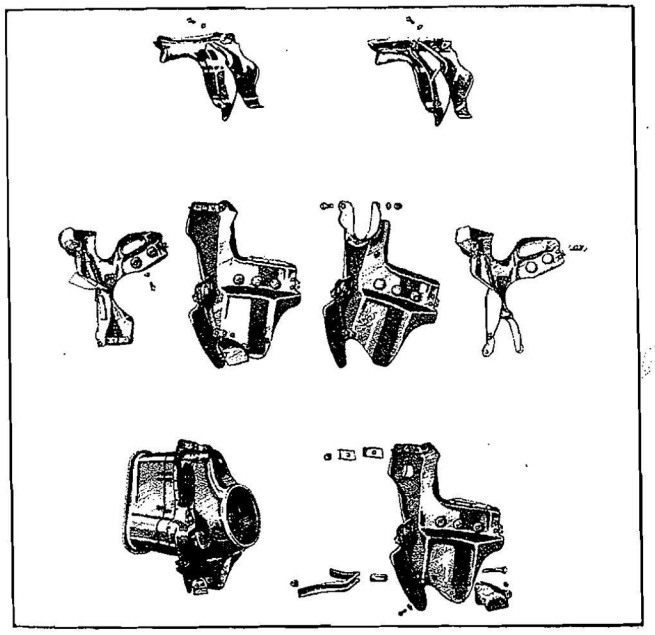

Figure 5—Air Deflectors

3. VALVE OPERATING MECHANISM.

The operation of the valves is accomplished through a cam which is located in the crankcase front section. The cam consists of a hardened steel ring with two sets of lobes on its circumference. Refer to Figure 6.

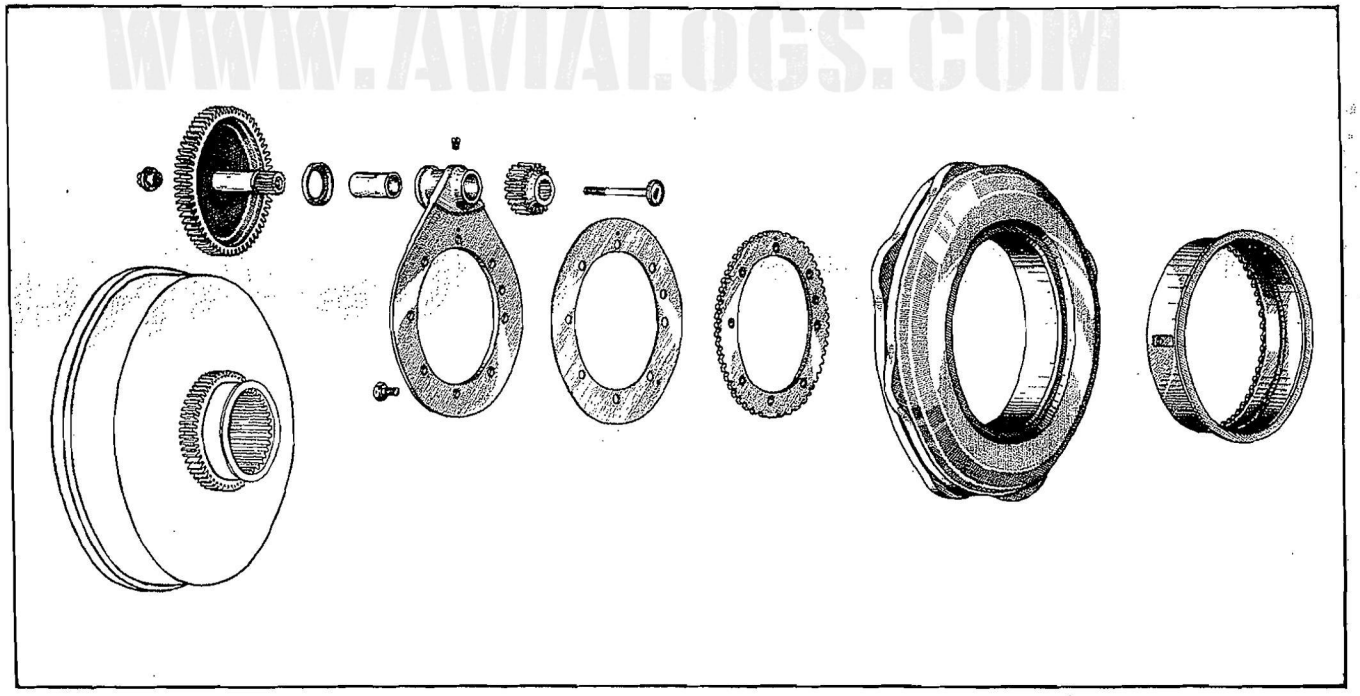

Figure 6—Cam and Cam Drive

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4. VALVES AND VALVE SPRINGS.

a. The intake valves are of the tulip type and the exhaust valves are of the mushroom type. Refer to Figure 7. Both types of valves are machined from forgings of heat resisting steel. The valve face angles are 44° 00′ to 44° 15′ for both intake and exhaust.

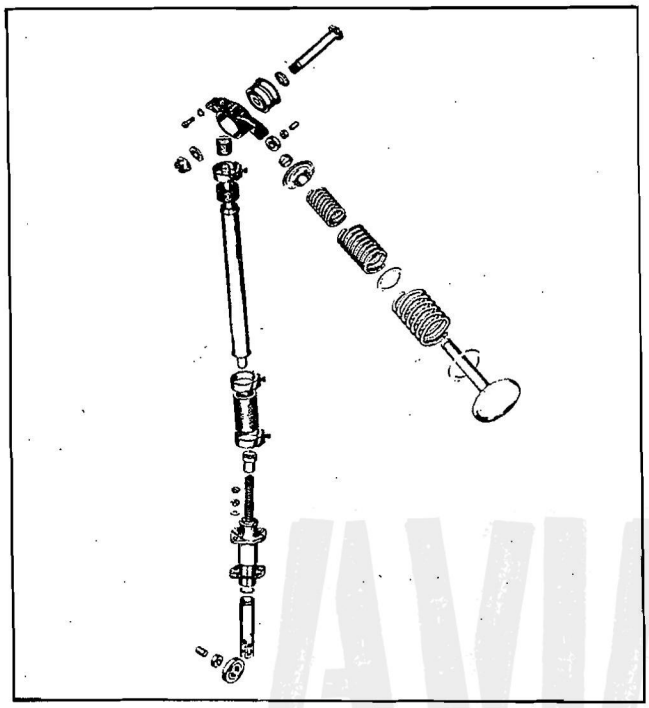

Figure 7—Valve Mechanism

b. The exhaust valve is hollow and is partially filled with sodium to assist in conducting heat from the valve head. To insure long life, stellite is welded on the seat of the valve.

c. The intake valve stems are smaller in diameter than the exhaust valves, and are of a solid cross section.

d. The intake and exhaust valves are fitted with three concentric coil springs which are interchangeable with each other.

e. The inner spring seats on a shoulder of the valve guide, while the intermediate and outer springs seat on the flat steel washers which rest on machined surfaces of the cylinder head. A shouldered steel washer is provided at the outer end of the springs and the assembly locked at the valve tip by a tapered, split lock ring.

5. CRANKSHAFT AND PROPELLER SHAFT CONSTRUCTION.

a. The crankshaft is of a two-piece construction, single throw type, machined from alloy-steel forgings. Refer to Figure 8.

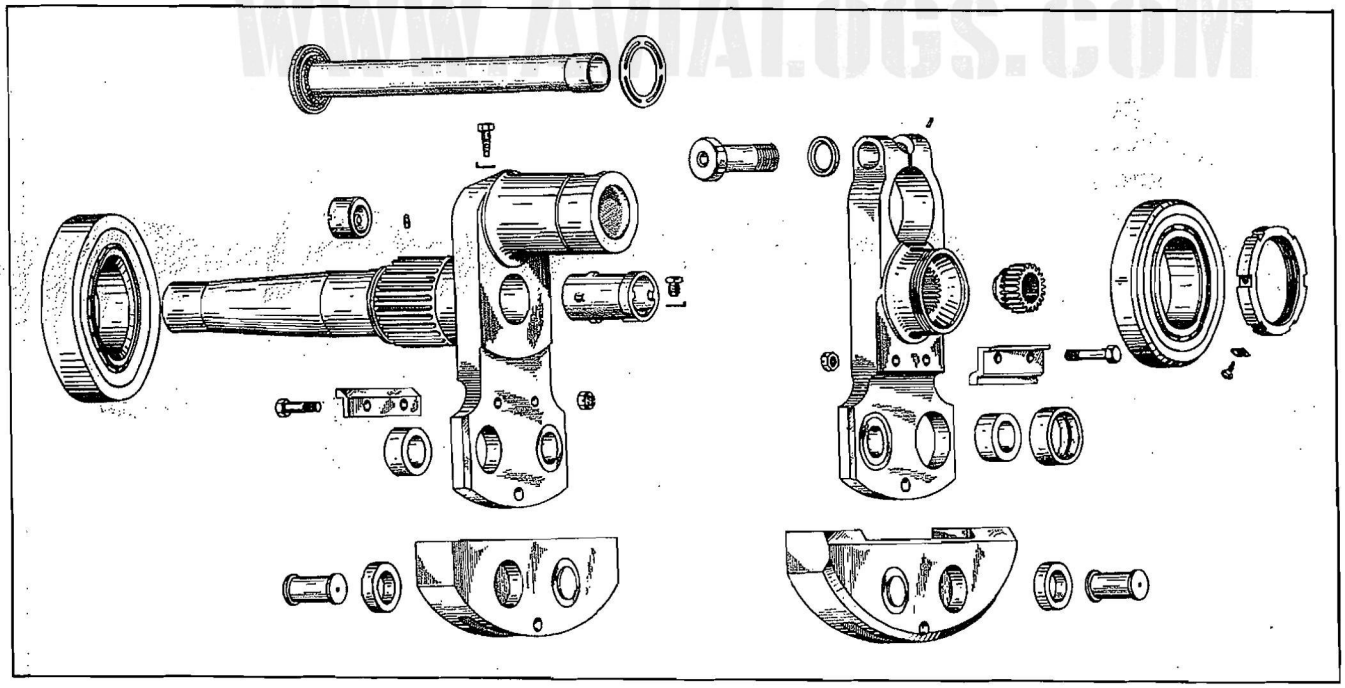

Figure 8—Crankshaft

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b. The front section of the crankshaft includes the drive shaft, front crankcheek, front dynamic damper counterweight, and the crankpin. The crankpin and drive shaft are bored for lightness throughout, except at the rear end of the crankpin where a web is left to prevent distortion when the rear crankcheek is clamped into position. On recent engines two crankpin oil tubes supply oil to the flats on the crankpin to lubricate the master rod bearing. These oil tubes help to eliminate sludge formation in the passages to the flats. A plug is pressed into the front end of the crankpin and is secured by a drilled cap screw which serves also as an oil metering jet. The hollow driveshaft is plugged at the crankcheek by a tight fitting plug which is secured in position by a tab lock and screw. In engines which breathe through the crankshaft, this plug is replaced by a breather tube support. The front crankcheek is of rectangular section drilled and slotted to accommodate the front dynamic damper and stops.

c. The rear section of the crankshaft includes the crankshaft rear crankcheek, rear dynamic damper, and crankshaft rear bearing journal. The upper end of the crankcheek is bored to receive the crankpin and is bored and threaded at the extreme upper end to receive the clamping screw. A slot is provided to permit a clamping action when the clamp screw is tightened.

d. The general appearance of the dynamic damper is the same as that of the conventional counterweight. It is, in principle, a pendulum counterweight. Each unit consists of a counterweight supported on two floating pins which pass through the extended portion of the crankcheek. The bushings in the rear dynamic damper assembly are of the floating type and lubricated by two oil passages drilled in the rear crankcheek. The component parts of the dynamic damper assemblies are locked to the crankshaft by stops bolted to the crankcheeks. The stops also limit the movement of the damper weights when the crankshaft is rotated slowly.

e. The crankshaft is supported in the crankcase by a roller bearing directly forward of the front crankcheek and by a roller bearing directly behind the rear crankcheek. Both bearings are of the demountable type, the front incorporating sixteen rollers and the rear bearing eighteen rollers.

f. The propeller shaft for the Model R-1820-65 and -97 engines is machined from a steel alloy forging and is hollow throughout its length. The shaft is supported by two steel-backed copper-lead bushings which ride on journals of the crankshaft front extension. A steel sleeve, shrunk in the propeller shaft between the two bushings, forms with the front bushing an annulus from which the hydro high pressure oil is taken for the operation of a hydromatic propeller. A flange forged integrally at the rear end of the shaft is drilled to accommodate the 24 pinion carrier ring attaching bolts. Refer to Figure 9. The flange is drilled with eight passages for pressure lubrication of the pinion bushings. The propeller shaft is threaded on its outside diameter near the mid-section for the thrust nut and at its front-end for a propeller hub nut. The shaft is also splined at its front end to receive a No. 50 propeller hub.

g. The propeller shaft for the Model R-1820-40, -60, -71, -73, and -87 engines is also machined from a steel alloy forging and differs from the propeller shaft used in the Models R-1820-65 and -97 only in the respect that the flange is in the form of a spider having six pinion arms. Refer to Figure 10. Each arm is drilled and fitted with bronze bushings which carry

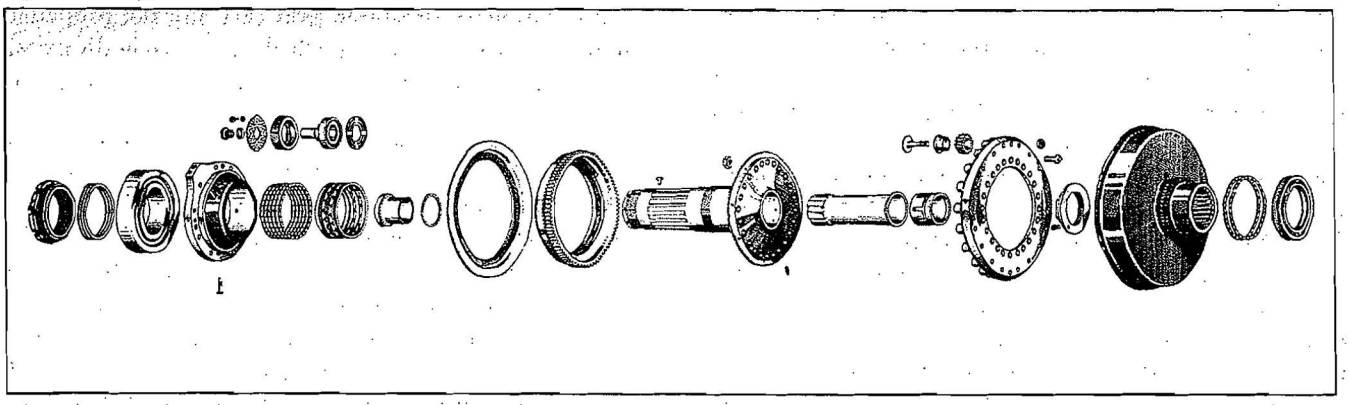

Figure 9—Propeller Shaft and Reduction Gear (16:9 Reduction)

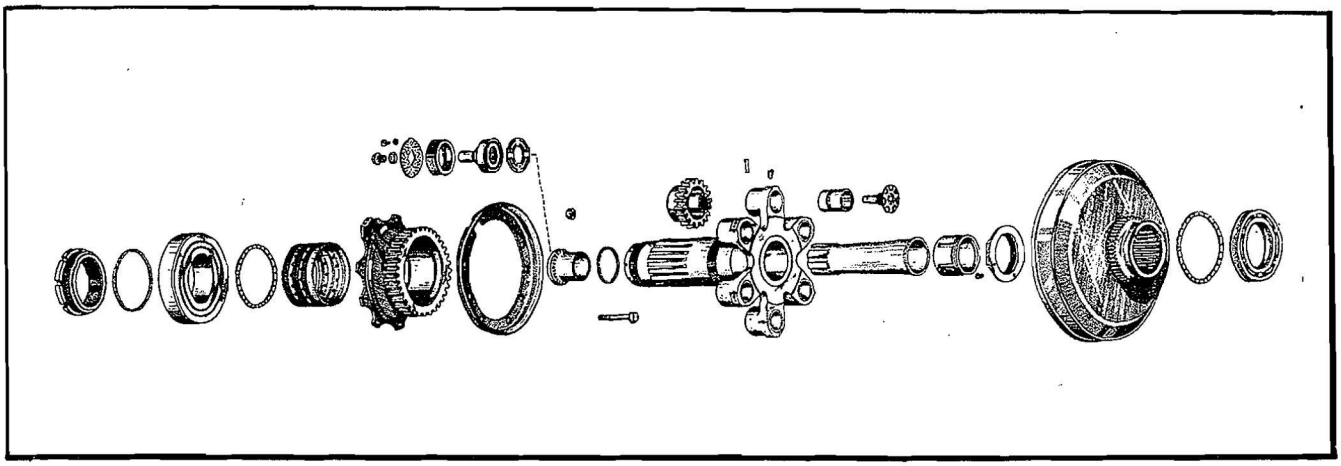

Figure 10—Propeller Shaft and Reduction Gear (3:2 Reduction)

the reduction gear pinions. The arms are also drilled with oil passages for pressure lubrication of the bushings.

h. The propeller shaft for the R-1820-54 engines is driven at the same speed as the crankshaft by means of a gear which is splined to the crankshaft in place of the reduction gear on the other engines. The flange which replaces the spider arms on reduction geared engines has teeth around its circumference which spline into mating teeth on the inside of the bell gear.

i. Since the Model R-1820-54, -65, -71, -73, -97, and some of the -60 engines used by the AAF breathe through cored passages in the supercharger front housing, the hollow propeller shaft is blanked off at its front end with a steel adapter which is drilled for oil passages to accommodate a hydraulic propeller. A cover plate may be inserted into the inside diameter of the propeller shaft to blank off the oil passages for use with a non-hydraulic propeller.

j. The Model R-1820-40, -40B, -87, and some of the -60 engines breathe through the crankshaft, and for this purpose the hollow crankshaft incorporates a breather tube. The anti-propeller end of the breather tube has an oil-tight fit in a support at the front crankcheek, while the flange at its propeller end seats on the propeller shaft front bushing. The annulus thus formed between the breather tube and the driveshaft acts as a reservoir for engine oil. The flange is drilled for two sets of holes to allow for the unrestricted flow of both hydro low and hydro high pressure oil to the propeller. A gasket, an adapter, and a retaining nut complete an oil-tight passage for the hydro oil to the propeller. A plug is used on the adapter to blank off the oil passages when a non-hydraulic propeller is used.

6. REDUCTION GEAR ASSEMBLY.

a. R-1820-65 AND -97—.5625 (16:9) REDUCTION GEAR RATIO.

(1) The reduction gear for the Model R-1820-65 and -97 engines consists essentially of a large internal driving gear splined and shrunk to the crankshaft; a propeller shaft assembly having twenty planetary type pinion gears mounted on a carrier ring which is bolted to the propeller shaft flange; a stationary reduction gear support which is bolted to the crankcase front section; and a stationary reduction gear meshing with the stationary reduction gear support and pinion assembly. Refer to Figure 9.

(2) The reduction gear drive is as follows: The reduction driving gear meshes with the planetary pinion gears causing them to travel around the rim of the stationary reduction gear carrying the propeller shaft to which they are attached in the same direction of rotation as the crankshaft but at 9/16 of its speed.

(3) The reduction driving gear is machined from a nitralloy steel forging with spur gear teeth cut inside the rim to drive the pinion gears. Splines are cut on the inside diameter of the hub for crankshaft attachment and teeth cut on the hub outside diameter form the cam drive gear. The outside rim is provided with a timing scale ranging from 0° to 35° for magneto and valve timing checks. Three tapped puller holes are located near the hub for disassembly purposes.

(4) The pinion carrier ring is machined from a steel forging with twenty integral, hollow trunnions upon which the pinion gears and bushings are supported. Each trunnion is drilled with two holes interconnecting an oil groove on its outside diameter.

(5) The twenty pinion gears are machined from steel forgings and are case hardened on the inside diameter and tooth surfaces. The bronze pinion gear bushings are plated all over with a thin coat of lead. The bushings are a loose fit in the pinions and on the trunnions. Each bushing is shouldered on its front end, drilled with six oil holes at its mid-section and spotfaced for identification marks on the front face of the shoulder. Twenty flanged head bolts and

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mating nuts are utilized for attachment of the pinions. The shank of each bolt is necked to allow for oil circulation.

(6) The stationary reduction gear is machined from an alloy steel forging and is tapped with twelve holes to accommodate the ten 3/8" and two 5/16" crankcase front section retaining bolts. The gear is mounted with a loose fit on the pilot of a support machined from an aluminum alloy casting. This support has an alloy steel sleeve shrunk in its inside diameter on which the hydro oil seal assembly rides. The sleeve and support are drilled for oil passages to and from the governor pump as described in paragraph 19.*b.*, of this section. A steel guard ring is supported between the stationary reduction gear and the support to eliminate damage to the reduction gear system in the event of a pinion accidentally becoming unattached.

(7) The hydro oil seal spacer assembly consists of a carbon steel sleeve which supports six cast iron rings in grooves cut in its outside diameter. The oil seal rings are arranged in groups of two on each side of the two drilled sections of the sleeve, where oil is transferred to and from the governor pump as described in paragraph 19.*b.*, of this section.

(8) Propeller shaft thrust is absorbed by a ball bearing having a wide inner race, either split or solid, which eliminates the use of a slinger ring customarily employed with this type of bearing. The front end of the inner race is grooved around its outside circumference to accommodate a puller for disassembly purposes. The balls are retained by two plates riveted together.

(9) The stationary reduction gear support attaching cap screws also retain the crankcase front section flange and spacer. The flange is machined from a carburized chrome nickel forging and is cadmium plated on all surfaces except the bore, in which the thrust nut oil seal rings revolve. The spacer is finish machined from an aluminum forging.

(10) The thrust nut, which limits the end movement of the propeller shaft in the thrust bearing inner race, is machined from carburized chrome nickel steel and has three oil seal ring grooves on the rear outside diameter. The front end is shouldered with eight slots cut into the rim for use of a spanner wrench. The three cast iron rings provide an effective seal against oil leakage, and prevent the thrust nut from rubbing directly on the flange.

b. R-1820-40, -40B, -60, -71, -73, AND -87—.666 (3:2) REDUCTION GEAR RATIO.

(1) The reduction gear for the Model R-1820-40, -40B, -60, -71, -73, -87 engines consists essentially of a large internal driving gear splined and shrunk to the crankshaft; a propeller shaft assembly incorporating six planetary type pinion gears mounted on arms which are integral with the propeller shaft flange and a stationary reduction gear which is bolted to the crankcase front section. Refer to Figure 10.

(2) The reduction gear drive is as follows: The reduction driving gear meshes with the planetary pinion gears causing them to travel around the rim of the stationary reduction gear. The pinion gears in turn carry the propeller shaft to which they are attached in the same direction of rotation as the crankshaft but at 2/3 of its speed.

(3) The reduction driving gear is identical with the gear used in the .5625 reduction gear ratio system. Refer to paragraph 6.*a.*(3) of this section.

(4) The six pinion gears are machined from steel alloy forgings and are case hardened on the inside diameter and tooth surfaces. Bronze nuts which screw into the pinions retain the pinions on the spider arms. Note that these nuts have left-handed threads. The hubs of the pinion gears are drilled for lubrication of the pinion gear bushings.

(5) The stationary reduction gear is machined from an alloy steel forging and is drilled and tapped to accommodate the crankcase front section retaining bolts. The gear is drilled with oil passages which index with similar passages in the crankcase front section to supply oil to and from the propeller governor pump. A steel guard ring is mounted at the rear of the gear to eliminate damage to the reduction gear system in the event of a pinion accidentally becoming unattached.

(6) The hydro oil seal spacer assembly is similar to the spacer used in the .5625 reduction gear system.

(7) The propeller shaft thrust bearing is essentially the same as that used in the .5625 reduction gear assembly.

(8) The stationary reduction gear attaching bolts also retain the pinion guard ring, crankcase front section flange, and spacer. The spacer and flange are similar in every respect to those used in the .5625 reduction gear system.

(9) For a complete description of the thrust nut refer to paragraph 6.*a.*(10) above for details.

7. CRANKCASE AND SUMP CONSTRUCTION.

a. The crankcase is built up of six principal sections located from front to rear as follows: Crankcase front section, crankcase front main section, crankcase rear main section, supercharger front housing, supercharger rear housing, and supercharger rear housing cover.

b. The crankcase front section is machined from a magnesium alloy casting. Refer to Figure 11. It supports the thrust ball bearing in a steel retainer which is shrunk into the forward portion of the section. A governor driveshaft in a bronze bushing is supported on the top center line of the section. The reduction gear assembly is also housed in this portion of the crankcase as previously described in paragraph 6 of this section. The crankcase front section is attached to the crankcase front main section by cap screws.

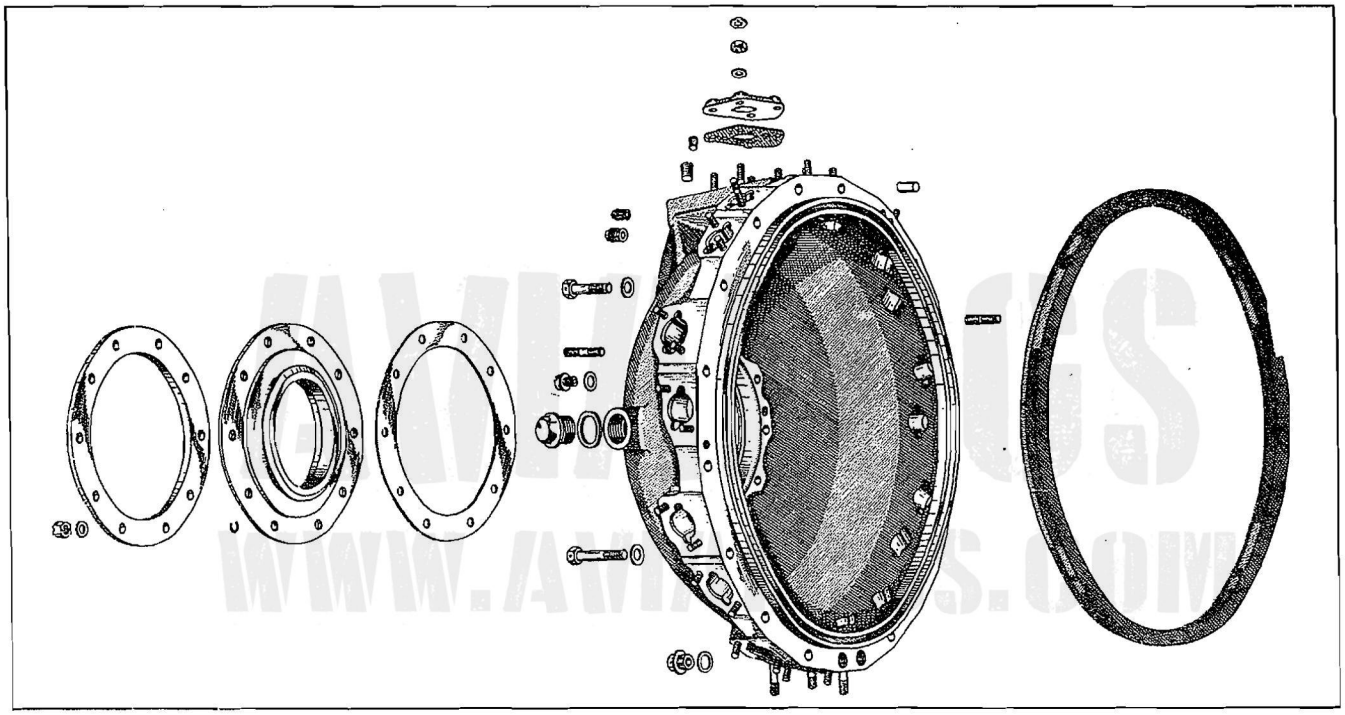

Figure 11—Crankcase Front Section

c. The main section of the crankcase consists of two alloy steel forgings which are parted at the cylinder center line and attached by short steel bolts through internal lugs. Refer to Figure 12. The forward wall of the crankcase front main section is provided with a hub extended at the center of the diaphragm to receive the cam bearing and cam. The bronze cam bearing is shrunk on the outside circumference of this hub. The front and rear roller bearings are assembled in steel bearing retainer rings which are shrunk into the diaphragms of the main section. A wide rubber oil seal ring is used between the front main section and the crankcase front section to form an oil tight joint. A narrow oil seal ring is used between the crankcase rear main section and the supercharger front housing.

d. The supercharger front housing is finish machined from a magnesium alloy casting having nine mounting lugs for supporting the engine and nine tapped bosses for intake pipe connections. The diaphragm of the supercharger front housing forms the forward wall of the diffuser section and distribution chamber. Refer to Figure 13. The impeller shaft front oil sleeve support is mounted on the diaphragm and held in place by a steel retainer ring which is secured to the diaphragm by eight short screws. This diaphragm is cored around the rim to form a breather passage. Of the six cored holes in the supercharger front housing breather passage, all but one are plugged. This one is equipped with a breather relief valve

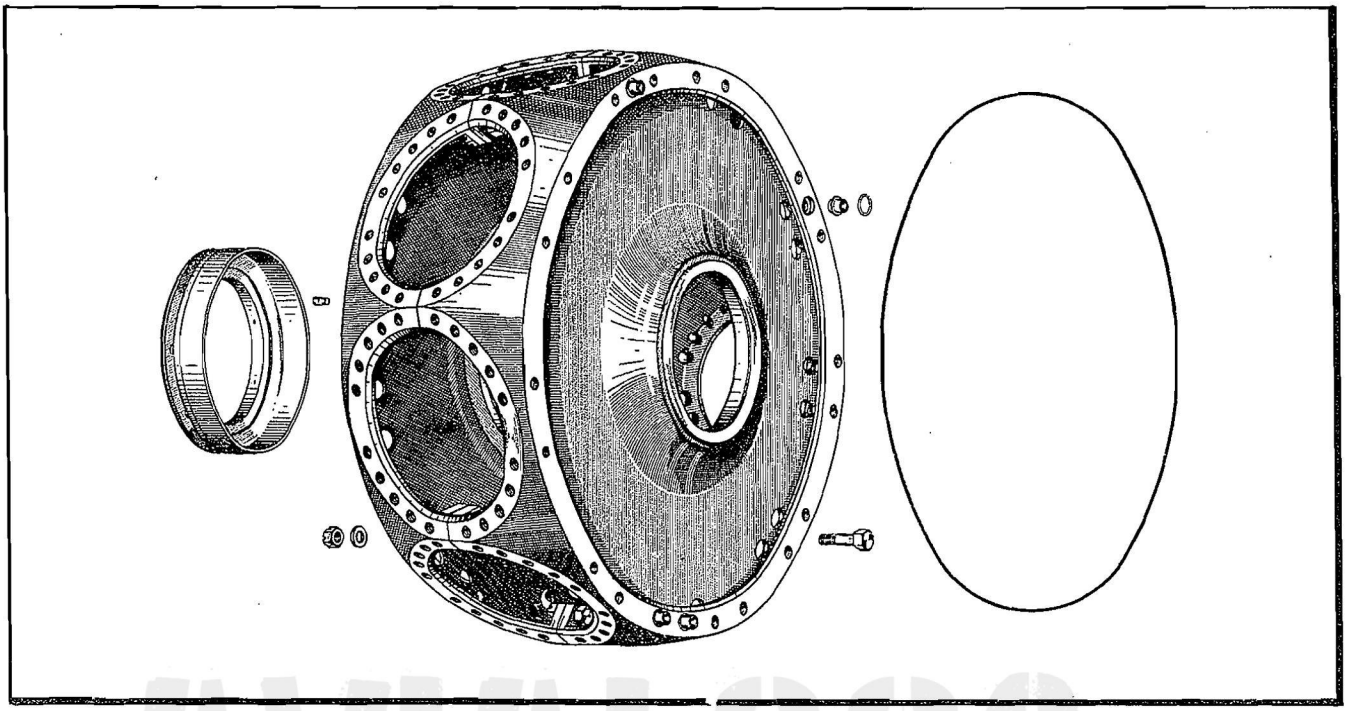

Figure 12—Crankcase Main Section

whose purpose is to provide a more direct outlet for any gases that create excessive pressure in the power section. Cored holes in the bottom of the housing form drainage and suction passages to the oil sump.

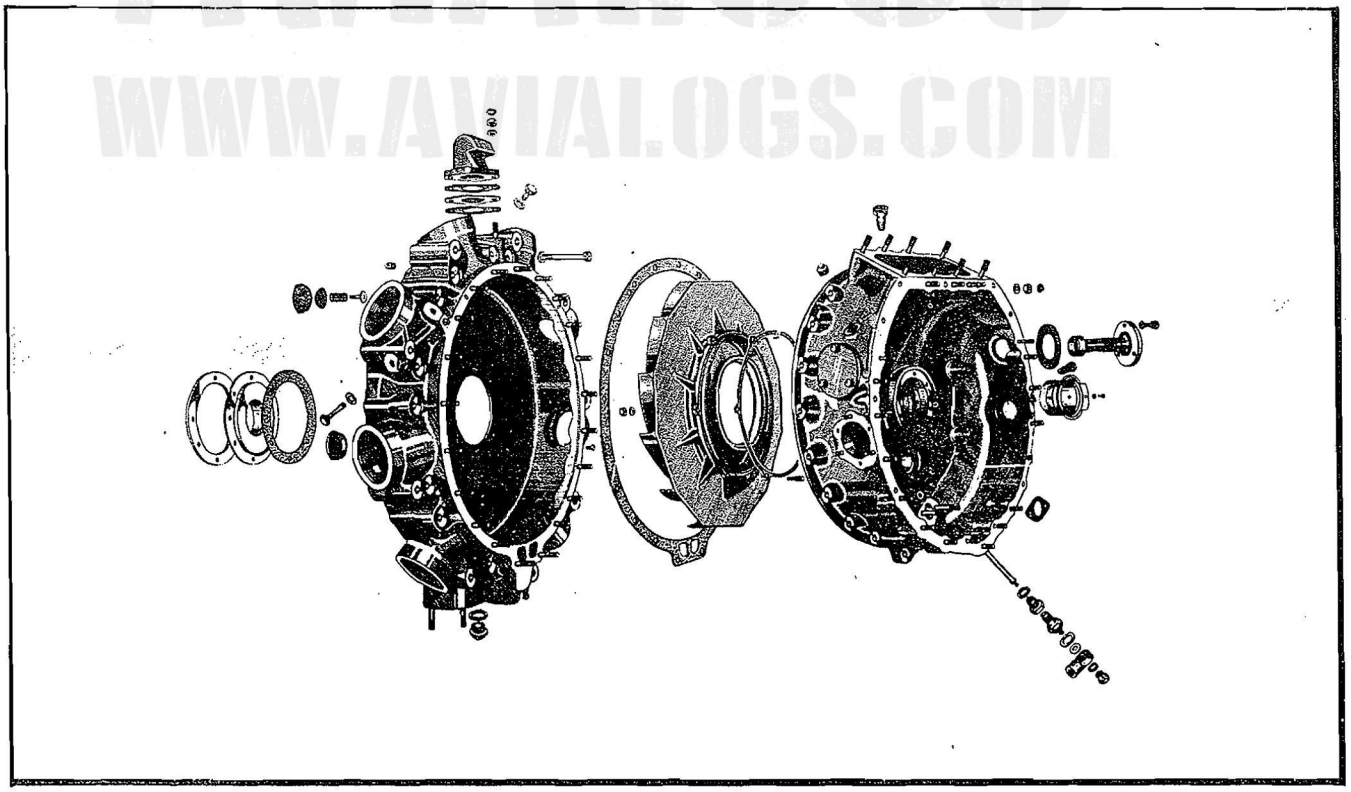

Figure 13—Supercharger Front and Rear Housings and Diffuser Plate

e. The magnesium alloy supercharger rear housing forms the induction passages to the impeller entrance and forms the housing for all the accessory drive gears. The vaned type diffuser plate is attached to the forward end of the induction passage, where it shrouds the impeller. The supercharger rear housing, which is attached to the supercharger front housing by studs, forms the rear wall of the diffuser chamber. A removable automatic oil filter is attached to the left side of the supercharger rear housing and seats near the center of the supercharger rear housing cover. Two gun synchronizers, except in the case of the R-1820-97 engines which have only one, or substituting covers, and a fuel pump are also mounted on the sides of this section. The impeller shaft oil seal assembly is supported in a steel sleeve which is shrunk into the center of the diaphragm, which forms the rear wall of the induction passage. Vent passages in the supercharger rear housing line up with similar passages in the supercharger front housing to equalize the pressure in the rear section and crankcase breather passages. Cored drainage and suction passages communicate with similar passages in the supercharger front housing.

f. The supercharger rear housing cover is machined from a magnesium alloy casting in the form of a heavily ribbed flat plate, and is secured to the supercharger rear housing by cap screws. Refer to Figure 14. The rear cover provides mounting pads for the two magnetos, generator, starter, oil pump, and dual accessory drive housing. Bushings in bosses on the front face of the cover form support for the accessory drive gears and the rear journal of the accessory drive and starter shaft. The cover is provided with the necessary pressure oil passages to lubricate all the accessory drives. Provision is made for an oil tank vent connection at the upper center of the cover.

g. The oil sump is a magnesium alloy casting of irregular shape as required to fit between No. 5 and No. 6 cylinders. The drainage capacity of the sump is approximately one gallon when the engine is stopped. The sump, however, is kept nearly dry in normal operation by the scavenge oil pump. The forward part of the sump is attached to the crankcase front section by studs and nuts. Attachment of the rear two arms of the sump to the supercharger is also obtained by studs and nuts. A screened plug is screwed into the lower forward end of the sump with the screen fitting into a pilot to keep any coarse, foreign material from entering the oil circulation. A drain plug which is equipped with a permanent magnet is screwed into the bottom of the sump to trap any foreign magnetic particles. The oil from the supercharger rear housing drains into the sump through holes in the left arm of the sump, while the holes in the right arm communicate with holes in the supercharger front housing for breathing purposes.

8. CONNECTING ROD CONSTRUCTION.

a. The connecting rod assembly consists of a mas-

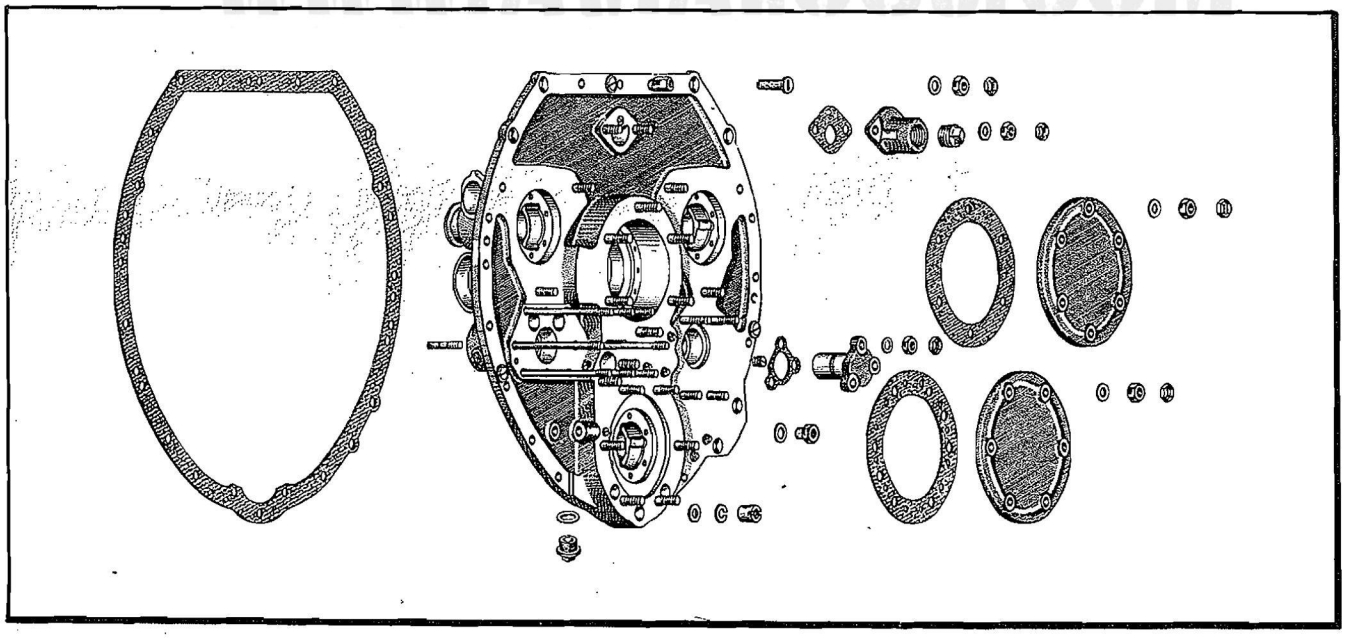

Figure 14—Supercharger Rear Housing Cover

ter rod and eight articulated rods attached to the master rod by knuckle pins. The rods are machined from a special I section alloy steel forging and heat-treated for high strength. Refer to Figure 15. Split type bronze bushings

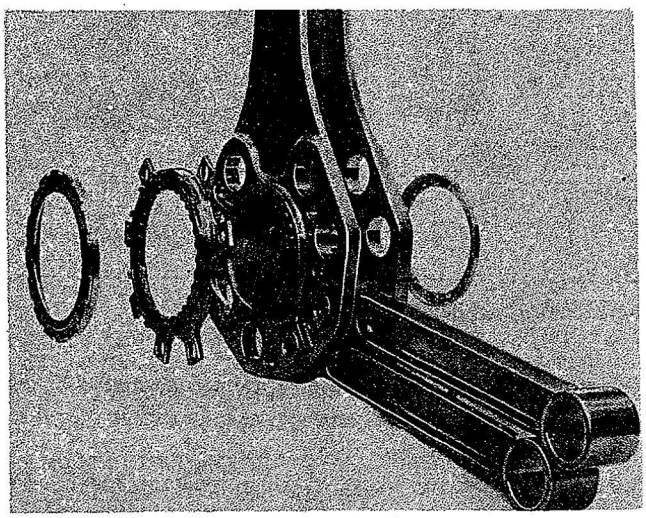

Figure 15—Master and Articulated Rods and End Seal Assembly

are pressed and spun in both the piston pin and knuckle pin bores of the articulated rods.

b. The web of the master rod shank is in the same plane as the crankpin axis, and the continuations of the flanges of the shank form the knuckle pin flanges. The piston pin end of the master rod is fitted with a split type bronze bushing. The crankpin end of the master rod is provided with a loose prefit silver bearing on some current production engines, but with copper-lead bearings on earlier engines.

c. A bearing end seal assembly is used on the master rod to improve the crankpin bearing lubrication by providing a seal against excessive oil leakage. The front end seal assembly consists of a steel knuckle pin locking plate and oil seal disk. The locking plate, which is bolted to the forward end of each knuckle pin, has splines which fit into those on the forward end of the master rod bearing to prevent the latter from turning in the rod. There is a recess in the front side of the knuckle pin locking plate into which the oil seal disk fits. Splines on the circumference of the disk mate with splines on the locking plate. The front face of the disk is held against the front crankcheek by the pressure of oil escaping from the crankpin bearing. The oil seal at the rear end of the crankpin bearing consists of a slotted and perforated spacer which fits over a boss on the rear face of the master rod.

d. The master rod operates in No. 1 cylinder.

e. The knuckle pins are made from alloy steel and have nitrided bearing surfaces to prevent scuffing. The nitrided bearing surfaces of the knuckle pins are also lapped and polished. One end of the knuckle pins is drilled and tapped to accommodate the locking screws. A step is cut into the tapped end of the knuckle pins to lock the pins and also line up the oil holes. An oil chamber is drilled in the center of the pins and sealed off with a pressed-in plug. Holes drilled through the walls of the pins permit adequate lubrication of the mating knuckle pin bushing.

9. PISTON AND PISTON PIN CONSTRUCTION.

a. The pistons are the full trunk type, machined from aluminum alloy forgings. Fins are machined on the inside of the skirt on the thrust and anti-thrust side. The pistons are recessed on top to provide adequate valve head clearance. Each piston employs six ring grooves, five above the piston pin bore and one below it. Refer to Figure 4. The top three grooves are slightly tapered and a wedge type ring is assembled in each. The three lower rings and grooves are of rectangular cross section. Holes drilled in the fourth and fifth grooves to the inside of the piston permit efficient circulation and control of the oil. The bottom ring is inverted so that the side marked "TOP" is toward the skirt of the piston. With its slightly larger circumference thus placed toward the top of the piston, this ring provides a pumping action to the oil and maintains a film of oil on the cylinder walls and piston.

b. Two types of piston pins and piston pin retainers are used. Both piston pins are machined from alloy steel, are of tubular construction and have a case hardened outer surface. The earlier type of piston pin is the shorter of the two, it has a ground bevel at each end and is retained in the piston by a coil spring retainer sprung into a groove in the pin bore of the piston at each end of the pin. The later type is longer, and is machined to receive a shouldered, aluminum, plug type retainer at each end. Both types of piston pins float in the piston and the connecting rod bushing. The plug type piston pin and retainers may be used in pistons that formerly employed the shorter piston pin and the spring coil retainers.

10. ACCESSORY DRIVE MECHANISM.

a. The supercharger and all of the accessories are driven by a forged steel extension shaft from the

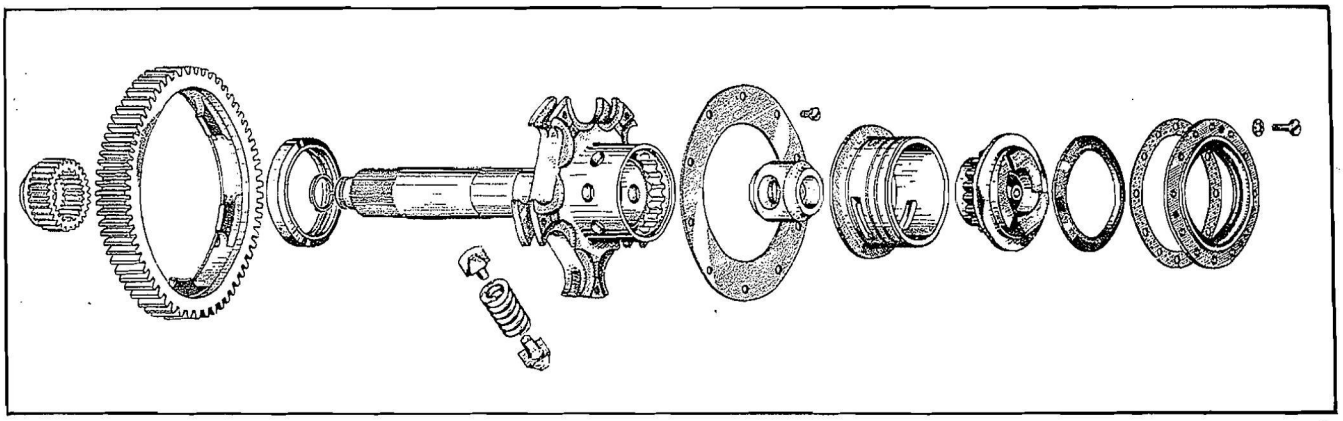

Figure 16—Accessory Drive and Starter Shaft

rear end of the crankshaft, through an accessory drive gear which is attached to the shaft by means of a flexible spring drive. The accessory drive gear is machined and case hardened from an alloy steel forging. Refer to Figure 16. The starter and accessory drive

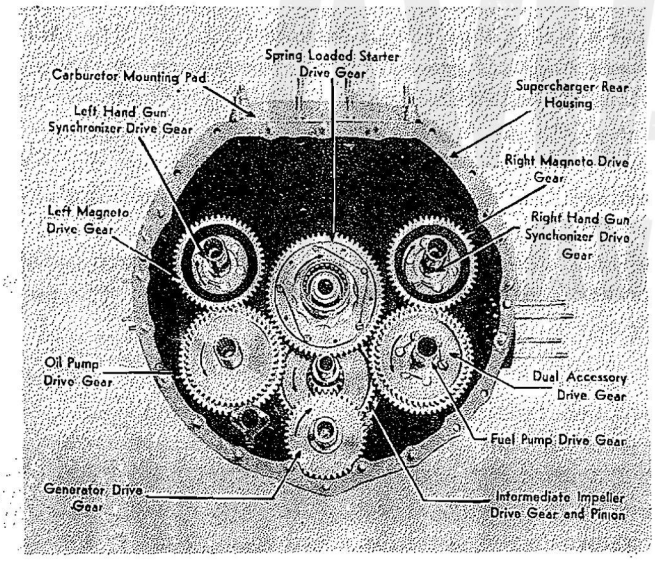

Figure 17—Location and Direction of Rotation of Accessory Drive Gears

shaft is splined at its front end to mesh with a coupling which is splined to the rear crankcheek. The shaft is supported at its rear end by a bronze bushing lined boss on the rear cover. The journal at the rear end of the shaft has involute splines cut into the inside diameter which mate with a detachable starter dog. Holes are drilled in the journal wall section for the main oil feed into the center-drilled shaft. Two journals on the starter shaft support the supercharger impeller shaft. The three- or twelve-jawed starter dog is made of alloy steel with splines on its front end which mate with splines at the accessory drive and starter shaft rear end. A hollow aluminum alloy spacer is installed between the starter dog and accessory drive and starter shaft at assembly and machined to a length assuring proper end clearance at the spherical oil seal ring which is supported on a pilot of the starter dog.

b. All principal drives are effected through spur gearing and are located in the supercharger rear housing with journals rotating in bushings pressed in bosses on the supercharger rear cover. Refer to Figure 17. The generator drive gear meshes with the supercharger intermediate drive pinion gear at the bottom. Refer to Figure 18. The supercharger intermediate drive gear is driven by the accessory drive gear. Both the oil pump and accessory drive gears are dual with the larger gear of each meshing with the accessory drive gear, and each of the smaller gears mating with a magneto drive gear. Refer to Figure 19. The gun synchronizer gears are spiral and mesh with gear teeth cut into the center of the

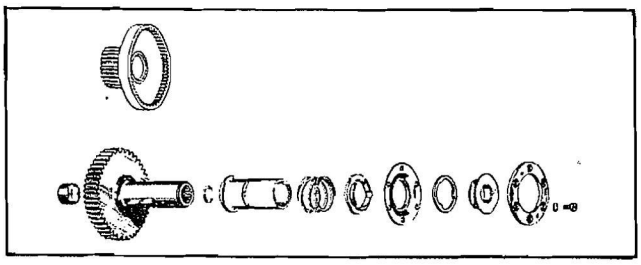

Figure 18—Generator Drive

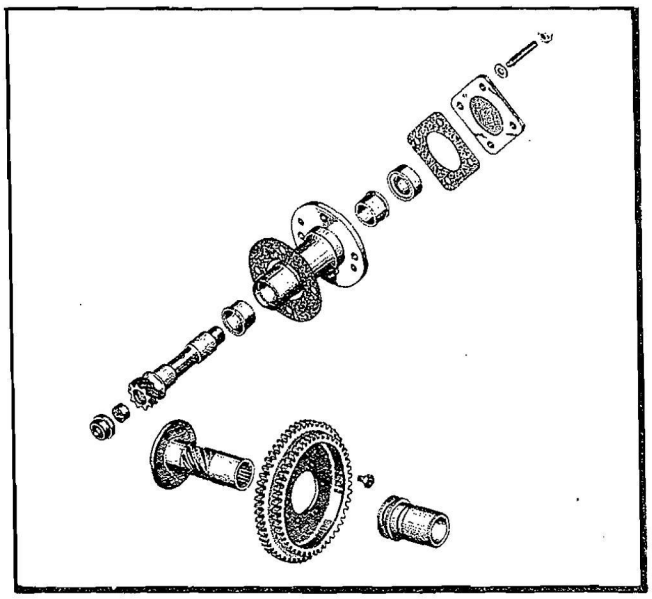

Figure 19—Fuel Pump Drive

magneto drive shafts. Refer to Figure 20. A spiral fuel pump gear meshes with a gear cut in the center of the accessory drive shaft.

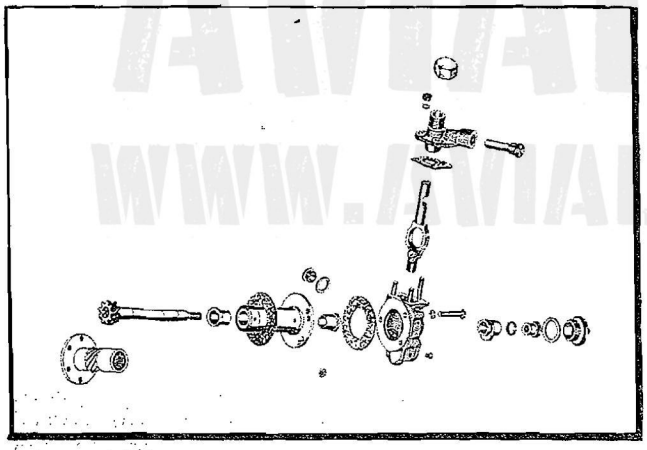

Figure 20—Gun Synchronizer Impulse Generator

c. The generator, oil pump, and fuel pump drive gears are machined from alloy steel forgings with integral gear and shaft. The magneto and dual accessory drive assemblies have forged steel gears attached to forged steel shafts by cap screws through the gear walls into the flanged shaft ends. Refer to Figure 21.

d. The accessory drive shaft, generator, and fuel pump drive shaft bushings are machined from cast bronze material. The accessory drive and starter shaft bushing is provided with three circumferential grooves and three slots to line up the oil holes in the accessory drive and starter shaft and the rear cover. The magneto, oil pump, and accessory drive bushings are machined from aluminum alloy. Each gun synchronizer is mounted in two bronze bushings which are pressed into an aluminum alloy support. The supports are attached to the sides of the supercharger rear housing. On engines where gun synchronizers are not to be used, substituting covers with integral plugs replace the gun synchronizer impulse generator supports.

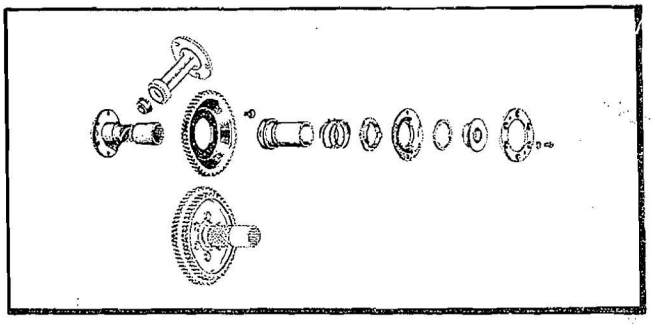

Figure 21—Magneto Drive

e. Provision for optional accessory drives is made possible by the use of a spur gear box attached to the supercharger rear housing cover at the accessory drive mounting pad. Refer to Figure 22. The gear box is composed of a magnesium alloy casting studded for attachment of aluminum alloy cover plate. The bushings which support the gears are divided between the cover plate and the body of the gear box. The main drive gear is machined integral with a shaft that extends through the upper left hand wall of the housing to mate with the accessory drive on the supercharger rear cover. This main drive gear meshes with an intermediate gear near the center of the housing to make up the primary or first gear train of the unit. The secondary train of gears, identified by their smaller teeth, consists of a secondary driving gear bolted to and turning with the primary intermediate

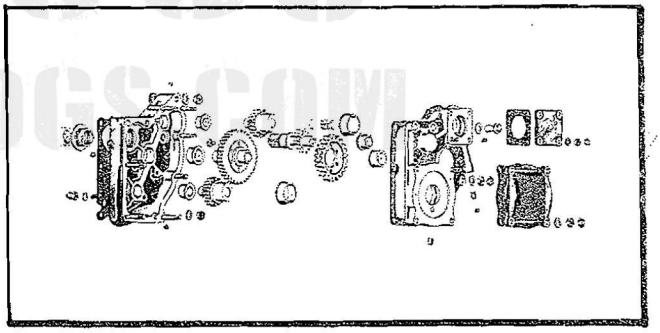

Figure 22—Dual Accessory Drive

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gear and meshing with two accessory driving gears. To change the speed ratio of the accessory drives to the crankshaft, it is only necessary to replace the two gears in the primary gear train. All the gears are machined from alloy steel forgings. The lower accessory drive is supported by oilite bushings and the upper drive is supported by an oilite bushing in the cover and a bronze bushing in the housing. All of the other drives in the unit are supported by bronze bushings. Both the housing and cover of the unit are drilled with oil passages as described in paragraph 19 b. of this section. Splined drives are utilized with provisions of conversion to the tongue type by the addition of steel couplings. An adapter equipped with drilled oil passages may be used on the lower drive if it is desired to mount a smaller accessory than the studs in the cover pad will accommodate.

f. TACHOMETER DRIVES.—Provision is made at the rear end of the oil pump for two tachometer drives, one electrical and one mechanical. The tachometer drives are effected by a small drive shaft which is splined at one end to mate with similar splines in the pressure oil pump drive shaft. Oil leakage is prevented by the use of spring loaded plungers and neoprene ring oil seals. The extended type is the mechanical tachometer and the flange type is the electrical. Both the tachometer drives have the same speed ratio, and rotate in a clockwise direction. Oil pumps incorporating an external oil scavenge line are equipped with only the electrical tachometer drive. However, an alternate arrangement is provided whereby two mechanical tachometer drives replace the electrical drive. An adapter, a pinion, two mechanical tachometer drive shafts, and a dual tachometer drive housing are assembled on the electrical tachometer drive pad to form the alternate arrangement. The drive is effected by the pinion which has a square tongue drive in the electrical tachometer drive gear and which meshes with the gears at the end of each mechanical tachometer drive shaft.

11. SUPERCHARGER.

a. GENERAL.—The centrifugal type supercharger consists of an impeller, a diffuser chamber, a distribution chamber, and an impeller drive mechanism.

b. IMPELLER.—The impeller operates with the inlet side facing the rear of the engine, and is mounted on a splined, hollow shaft which is supported by journals on the crankshaft extension. Refer to Figure 23. The impeller shaft is machined from a steel forging

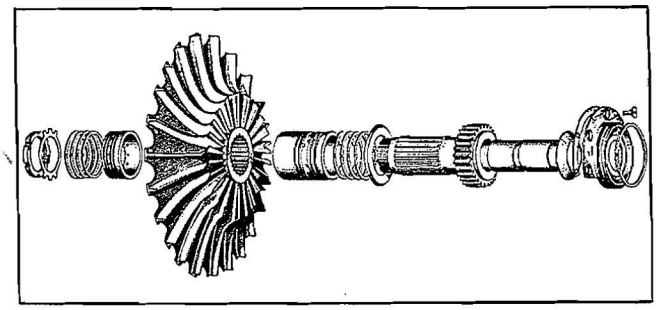

Figure 23—Supercharger Impeller and Impeller Shaft

with spur gear teeth on its rear end, and two steel backed bronze bushings pressed in its inside diameter at each end. The impeller thrust is absorbed by a self-aligning bronze thrust washer which makes a spherical seat on a steel retainer equipped with an oil seal ring and secured to the supercharger rear housing by flat head screws. A bronze thrust washer is provided in front of the impeller shaft gear and a laminated shim beneath the steel retainer attaching flange for end clearance adjustment. Steel oil seal sleeves each grooved to accommodate four bronze oil seal rings are slid on the impeller shaft at the front and rear ends of the impeller and the whole assembly retained by a nut and nut lock at the threaded front end of the shaft. As explained in this section, the front and rear impeller oil seals are supported by steel sleeves in the front and rear supercharger housings and the induction passage to the impeller is cast into the upper part of the supercharger front housing. A steel tube extends from the top of the supercharger rear housing, at the rear wall of the induction passage, to an annulus around the midpoint of the impeller rear oil seal assembly. This tube vents the impeller front and rear oil seal assemblies to the atmosphere by means of two splines omitted from the impeller shaft. Venting at this point prevents oil from leaking into the diffuser section by rendering ineffective any suction or pressure that might arise at either impeller oil seal.

c. DIFFUSER CHAMBER.—As described in this section, the aluminum alloy diffuser plate is attached to the supercharger rear housing by flat head screws. This plate shrouds the impeller and forms narrow passages through which the mixture is discharged into the distribution chamber or front supercharger housing. The front face of the diffuser is formed by the diaphragm of the front supercharger housing. Vanes cut on the diffuser plate form curved passages which guide the mixture into the distribution chamber.

d. DISTRIBUTION PASSAGE.—The distribution chamber is an annular passage in the supercharger front housing around the diffuser chamber. The nine intake pipes are attached to the circumference of this section through tapped radial ports. The rear wall of the chamber is formed by the supercharger rear housing.

e. SUPERCHARGER DRAIN VALVE.

(1) A drain passage is provided from the lower rear portion of the supercharger inlet chamber to the bottom of the supercharger rear housing to prevent the accumulation of excess fuel. A check valve drops by gravity when the engine is not running to allow drainage of the excess fuel to the atmosphere. When the engine is running, the check valve is pulled into its seat by the suction in the passage and prevents air from entering the chamber. A restricted air bleed is provided, however, through a small diameter return tube that leads up through the drain passage to the mouth of the impeller. During engine operation, any fuel that runs down the walls of the induction passage is prevented from draining to the atmosphere by the closed check valve and is drawn into four holes drilled at the base of the return tube above the air bleed where it is atomized and delivered to the impeller.

(2) Engines equipped with turbo superchargers, as are the Model R-1820-65, -73, and -97 engines, use a special supercharger drain valve assembly. This drain valve differs in operation from the conventional type of drain valve only when the pressure in the induction passage at the mouth of the impeller is at or above atmospheric pressure. These conditions exist when the turbo supercharger is in operation. Under these conditions, there is little or no suction retaining the disk valve in its seat, and the disk tends to drop, thus opening the drain valve to the atmosphere. At this point, manifold pressure acts on a piston fixed to the top of the disk valve to break the remaining suction on the disk and to press it firmly against the outlet flange in the drain valve body, thereby sealing the drain valve against atmospheric pressure. For this purpose, the manifold pressure is conducted from the distribution chamber, through drilled passages in the supercharger rear housing wall, and through the drain valve body to the top of the piston. The mixture at manifold pressure also proceeds through a ball check valve opposite the piston and passes through the jet into the return tube, drawing with it atomized fuel. This mixture issues at the mouth of the impeller where at all times the pressure is less than manifold pressure.

12. SINGLE-SPEED SUPERCHARGER.

a. The single-speed supercharger drive unit consists of an impeller drive and pinion gear (7.0:1 ratio) which rotates in a bushing in the supercharger housing rear cover at one end and another bushing in the supercharger rear housing web at the other end. Refer to Figure 24.

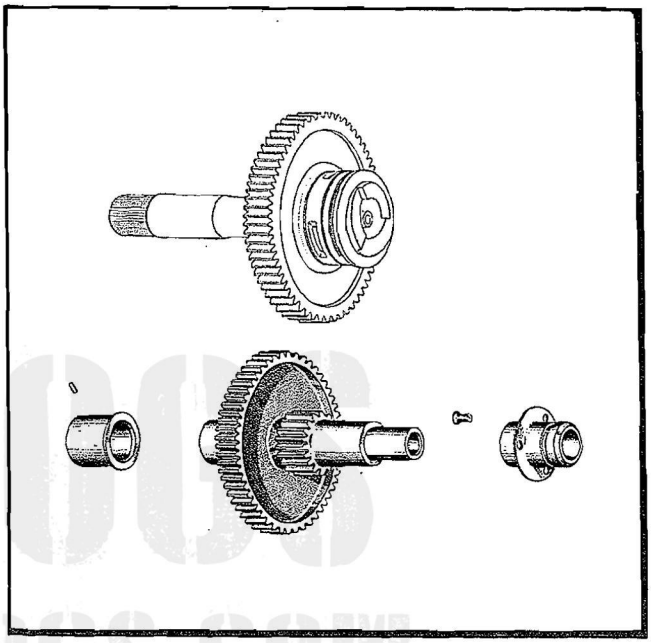

Figure 24—Single-Speed Supercharger Drive

b. The drive for the impeller is from the accessory drive gear to the impeller drive and pinion gear to the impeller gear.

13. TWO-SPEED SUPERCHARGER DRIVE (ROLLER CLUTCH TYPE).

a. The Model R-1820-87, -54, -60, -40B, and some of the -40 engines incorporate a two-speed supercharger which is actuated through the use of a roller clutch assembly. This assembly replaces the impeller drive gear and integral pinion used in single speed engines. In the roller clutch assembly, two separate gears correspond to the dual impeller drive gear of single speed engines, namely, the impeller drive gear, and the intermediate impeller drive gear. These gears are connected through the use of a cam and roller assembly for low speed operation, and by means of a stationary hydraulic multi-plate clutch assembly and a planetary gear system for high speed operation. Refer to Figure 25.

b. The cam and roller assembly includes a steel retainer, ten steel rollers and a steel cam. The retainer is bell-shaped and acts as an outer race for the ten steel rollers which are retained in position by a bronze cage. The hub of the retainer is splined to the intermediate impeller drive gear. The cam is splined on its inside diameter to the intermediate impeller driveshaft, and it acts as an inner race for the ten rollers.

c. The stationary hydraulic multi-plate clutch is located in a recess in the front face of the supercharger rear housing cover. A piston, fitted with an oil seal ring, operates in a steel sleeve pressed in the rear cover. Splines on the lower portion of the piston mate with similar splines in the sleeve. Forward of the piston are four friction disks which are splined on their inside diameters to an adapter which, in turn, is splined to the intermediate impeller driveshaft. The disks are separated by three steel plates which spline on their outside diameters to the clutch housing. The housing is secured to the rear cover by studs, washers, nuts, and cotterpins.

d. Oil pressure back of the piston presses the disks and plates against the clutch housing, thereby holding the intermediate impeller shaft stationary by means of friction existing between the clutch plates and disks. The clutch is released by allowing the oil to drain from behind the piston. Release of the clutch is also aided by a coil spring which is compressed between the piston and clutch housing at assembly, and which exerts a constant backward pressure on the piston. When the clutch is disengaged, the steel plates which are splined to the clutch housing remain stationary, and the friction disks are allowed to rotate with the intermediate impeller driveshaft to which they are splined.

e. The planetary gear system operates inside the impeller drive gear which has internal teeth cut on its inside diameter. This internal gear acts as the bell gear for the planetary system which includes four pinions that ride in a cage and mesh with a sun gear which is integral with the intermediate impeller driveshaft. The cage is split through the center and is held together by two indexing pins and by four cap screws. The rear half of the cage is splined to the intermediate impeller drive gear.

f. The clutch is controlled by a push-pull selector valve which connects corresponding oil passages to provide oil pressure behind the hydraulic clutch piston, or to cause this oil to drain. When the hydraulic clutch is engaged, it holds the intermediate impeller driveshaft stationary, causing the planetary gear drive to become effective, and thereby producing high speed operation. When the hydraulic plate clutch is disengaged, all supercharger operation is effected through the cam and roller assembly which produces the low ratio speed.

g. For low speed operation, the impeller drive is obtained from the accessory drive gear through the intermediate impeller drive gear to which both the roller retainer and the planetary pinion cage are splined. A reaction in the planetary system causes the rollers to become wedged between the cam surface and the retainer, causing the movable parts of the clutch to lock and turn as a unit, the resulting drive is similar to the single speed supercharger drive. The following parts form this driving unit: The intermediate impeller drive gear; the retainer, which is splined to this gear; the cam, which is locked to the retainer by the wedged rollers; the intermediate impeller driveshaft to which the cam is splined (and its integral sun gear); the pinion cage, which is splined to the intermediate impeller drive gear; the planetary pinions, which are held stationary by the fixed sun gear and cage; and the impeller drive gear, which is held fixed in the unit by the stationary pinions.

h. High ratio operation is obtained when the engaged hydraulic clutch holds the following parts stationary: the intermediate impeller shaft and its integral sun gear, and the roller clutch cam which is splined to the shaft. Under these conditions, the impeller is driven by the accessory drive gear, through the intermediate impeller drive gear to which the pinion cage is splined, and through the planetary system and impeller drive gear to the impeller shaft gear. During high ratio clutch operation, the roller clutch becomes ineffective since the motion of the retainer relative to the fixed condition of the cam causes the rollers to be located on the low levels of the cam surface.

14. TWO-SPEED SUPERCHARGER DRIVE (PLATE CLUTCH TYPE).

a. Some of the Model R-1820-40 engines incorporate a two-speed supercharger which is actuated through the use of a plate clutch assembly. This consists of a high-speed ratio drive supplemented by a planetary gear reduction system which, when engaged, produces the low-speed ratio drive. A plate clutch is housed in the supercharger rear housing cover to

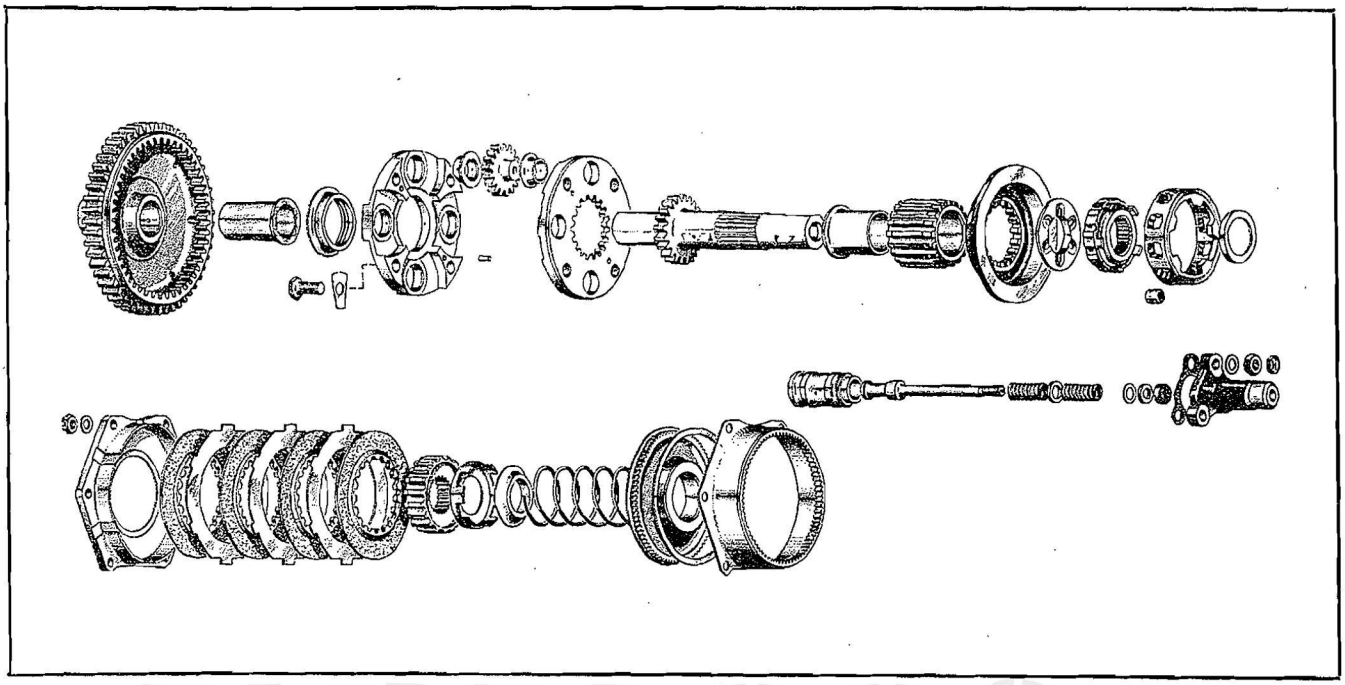

Figure 25—Two-Speed Roller Clutch Supercharger Drive

effect the low ratio drive while a second plate clutch, housed in the impeller drive gear, actuates the high ratio drive. The high ratio clutch revolves with the impeller drive gear while the low ratio clutch remains stationary in the supercharger rear housing cover. The speed change is obtained by means of a manually operated control valve which regulates the flow of oil to either clutch, thereby engaging the selected clutch. Refer to Figure 26.

b. The supercharger ratio is selected by the manual operation of a two-position selector valve. This valve is of the push-pull type and is located on the lower left side of the supercharger rear section cover. A spring is used in the control valve assembly to ensure that the valve remains in its full forward position when the engine is operated in LOW supercharger drive ratio. The valve is operated by a suitable cockpit control and connecting linkage.

c. The operation of the drive through the low ratio gear is as follows: Engine oil under pressure is led from a passage in the rear cover, through the control valve, and into a chamber behind the low-speed clutch piston by way of another drilled passage.

d. The low-speed clutch piston is moved forward by the oil pressure which in turn presses the clutch plates and disks together. As the clutch plates and disks engage, the low-speed planetary sun gear becomes stationary, thus obtaining the low ratio through the planetary gear drive. At the same time the high ratio clutch plates and disks are disengaged by a coiled spring built into the clutch. In low ratio, therefore, the drive is from the accessory drive shaft gear to the small bell-shaped intermediate driving gear; through this gear to the five planetary pinion gears and intermediate impeller drive shaft, on which the pinion gears are mounted; through this shaft, which is splined to the impeller drive gear at the forward end; and thence to the impeller shaft gear.

e. The high gear ratio is obtained by means of engine oil pressure in the following manner. With the control valve in the extreme rearward position, engine oil passes through the control valve from a drilled passage in the rear cover; then through another drilled passage in the cover into the hollow intermediate impeller drive shaft, where it passes through a check valve in the forward end of the shaft; then through drilled holes in the shaft and into the chamber behind the high-speed clutch piston. The piston moves toward the rear of the engine under the action of the oil pressure, thus engaging the clutch plates and disks and locking the bell-shaped, intermediate impeller drive gear to the impeller drive gear through a splined adapter in the high ratio clutch.

f. Changing the position of the selector valve from low ratio to high ratio not only supplies oil to operate the high ratio clutch, but also cuts off the oil flow to the low ratio clutch, at which time the action of the spring built into the low ratio clutch releases clutch plates, disks, and piston. As the piston moves toward the rear of the engine, oil in the chamber behind the piston is forced out through a passage in the rear cover and drains into the supercharger rear housing. The planetary sun gear is now disengaged, thus permitting the planetary reduction gears to turn freely and the low-speed clutch becomes inoperative.

g. In high ratio the drive is from the accessory drive gear to the propeller end of the bell-shaped intermediate impeller drive gear; from the intermediate impeller drive gear through the high ratio clutch and gear to the impeller shaft gear and shaft.

15. IGNITION.

a. Ignition is supplied either by two Scintilla SF9LN4, two American Bosch SF9LU3 or two Edison-Splitdorf SF9LD1 magnetos attached to the supercharger rear cover. Refer to Figure 27. The magnetos incorporate nine lobe breaker point cams which turn at ½ crankshaft speed. The pivotless type breaker points are employed. Both magnetos are timed to No. 1 cylinder after which they operate with fixed timing. The right hand magneto fires the front spark plugs and left hand magnetos fires the rear spark plugs. Section VIII of this Handbook gives timing instructions and AAF T. O. No. 03-5DA-2 or NavAer 03-5DA-534 contains complete information on the Scintilla SF9LN4 magnetos. Refer to AAF T. O. No. 03-5DC-1 or NavAer 03-5DC-512 for information on the American Bosch SF9LU3 magnetos.

b. The ignition wire is rubber insulated and covered to prevent wear and deterioration. A manifold extending around the outside of the crankcase front section at the parting surface conducts the ignition leads to the front and rear spark plugs of each cylinder. All parts of the ignition wire assembly are shielded to eliminate radio interference. Refer to Figure 28.

c. Spark plugs C35S and ACLS87 may be used interchangeably for replacement. The following spark plug models are approved for Navy engines: Champion C-34-S, Aero LS-4AD-1, Bendix 6S-9A and BG LS-465A. Complete information on servicing of spark plugs will be found in AAF T. O. No. 03-5E-1 or Navy T. O. No. 41-39 and Navy TN 78-42.

16. CARBURETION.

These engines are equipped with Bendix Stromberg Injection carburetors:

R-1820-65, -73, -97	PD-12H2
R-1820,-40, -40B, -54, -71, -87	PD-12H3
R-1820-60	PD-12K4
	PD-12K10

17. AIR DEFLECTORS.

Pressure type, close fitting cylinder head and barrel baffles of sheet aluminum alloy are used to direct the flow of air through the cooling fins with maximum efficiency. Refer to Figure 5.

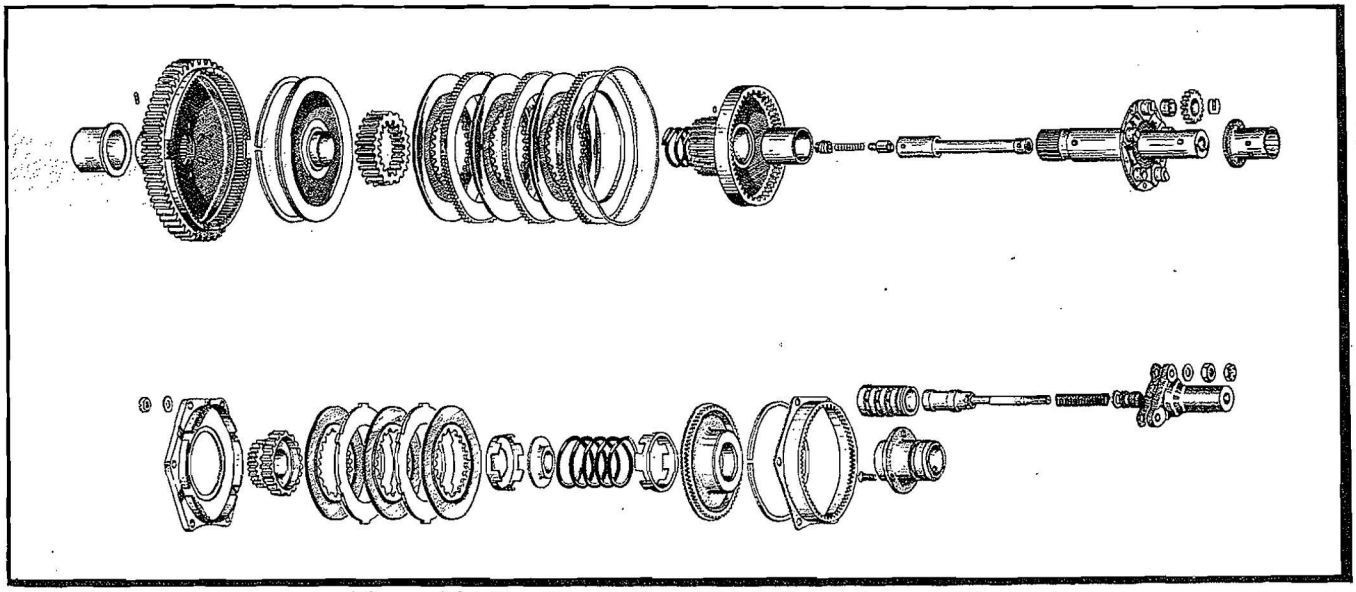

Figure 26—Two-Speed Plate Clutch Supercharger Drive

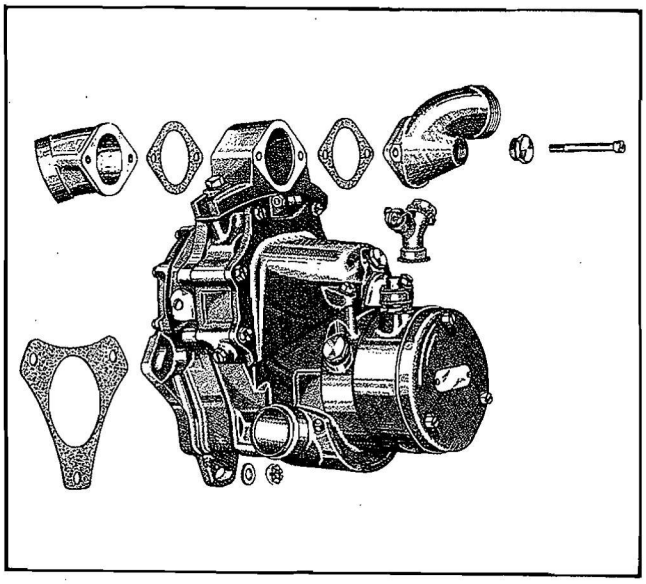

Figure 27—Magneto

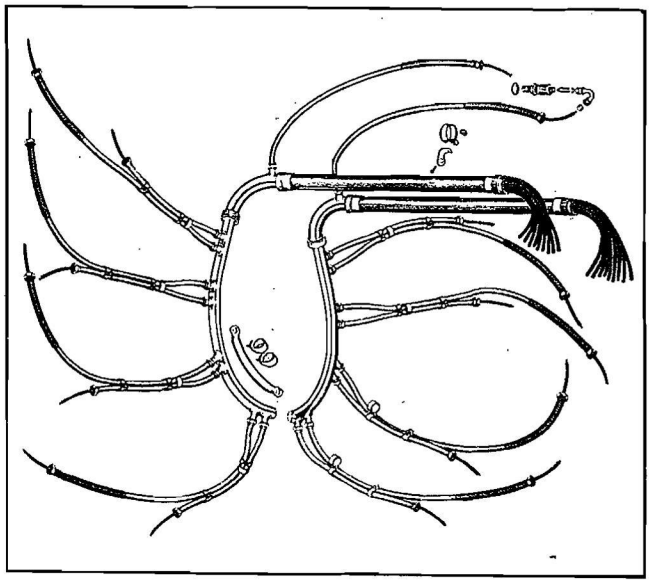

Figure 28—Ignition Harness

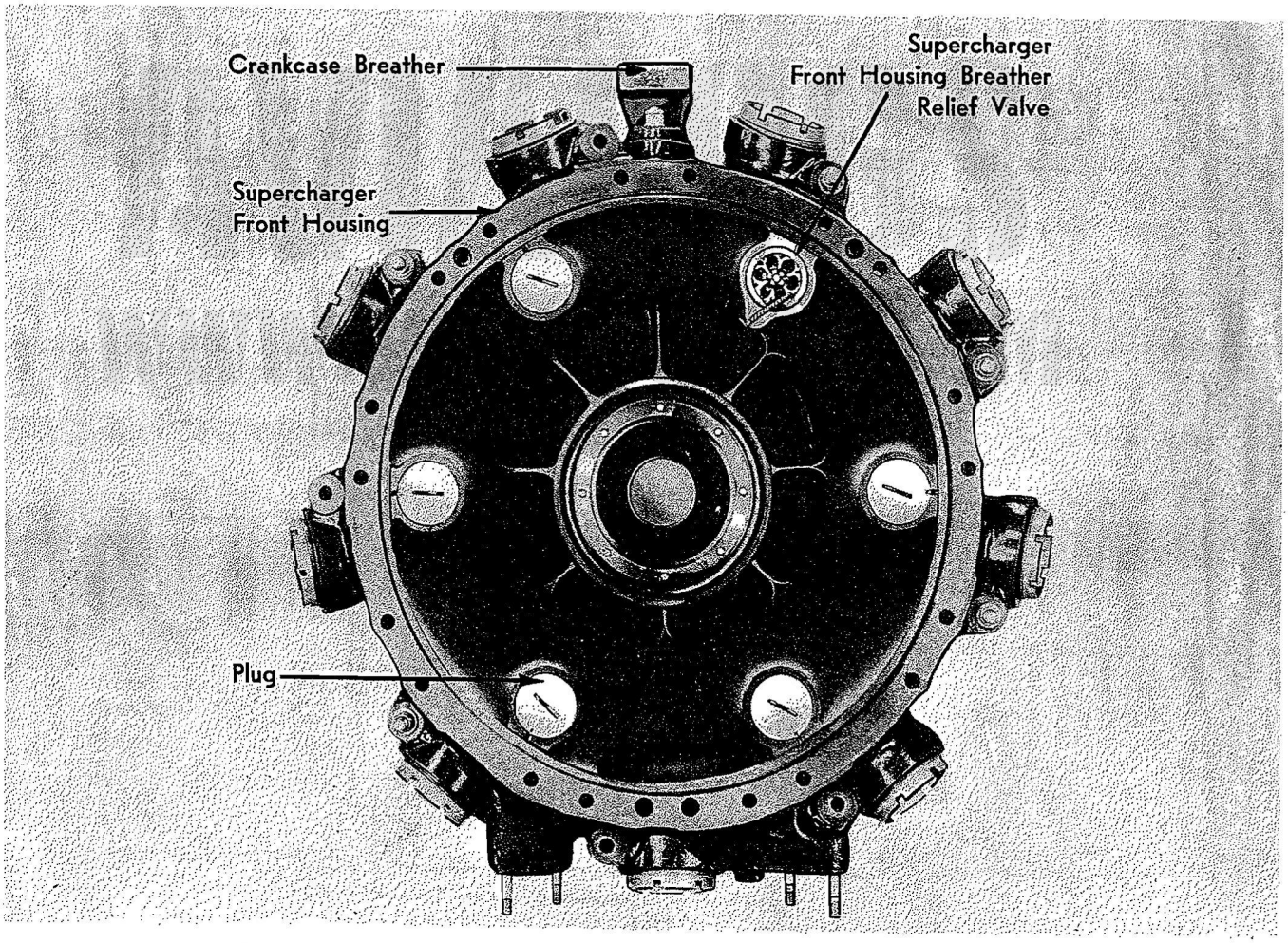

Figure 29—Location of Supercharger Front Housing Breather Relief Valve

LUBRICATION DIAGRAM

R-1820-65 AND ASSOCIATED MODELS

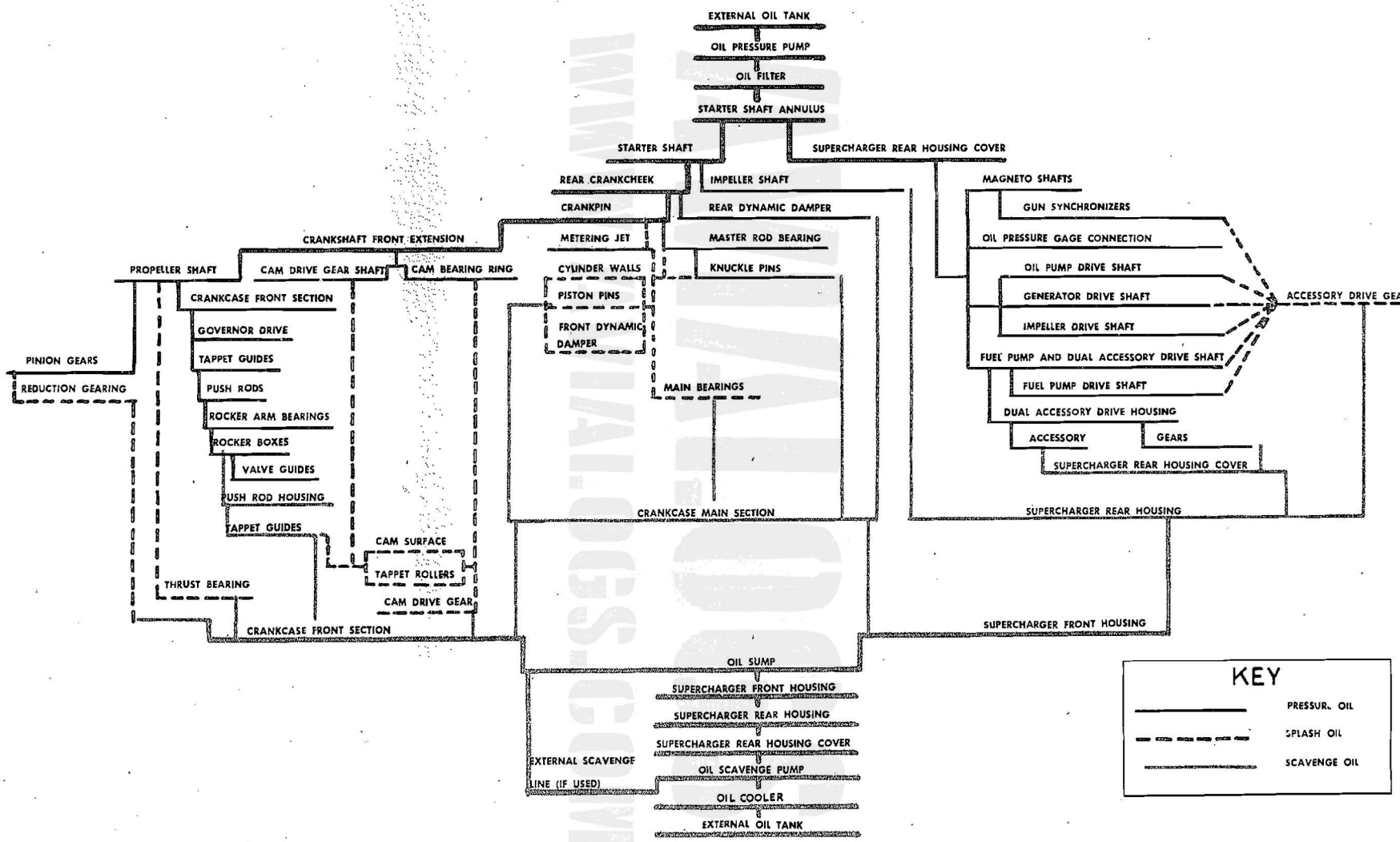

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Figure 30—Lubrication Diagram

18. CRANKCASE BREATHER.

a. R.-1820-54, -65, -71, -73, -97, and some of the -60 engines, used by the AAF, breathe entirely through the cored passages in the supercharger front housing as previously mentioned in this section.

b. Crankcase vapors enter the sump through the crankcase oil drain holes, where they pass around a ribbed section and out of a port in the right arm of the sump. Leaving the sump the vapors pass through a cored passage around the rim of the supercharger front housing. Arriving at the top of this passage, the vapors pass into the atmosphere through an outlet which is secured to the top of the supercharger front housing.

c. A spring-loaded relief valve located in the upper section of the cored passage opens to give the crankcase vapors a short, direct route to the atmosphere in the event abnormal pressure builds up in the crankcase. Refer to Figure 29. This is a flat steel disk valve which seats in a bronze insert screwed into the passage front wall section. The aluminum alloy plugs installed in the front wall section are installed for manufacturing reasons and have no bearing on the breather system.

d. The model R-1820-40, -40B, -87, and some of the -60 engines breathe through the crankshaft. They incorporate a breather tube and an adapter inside the hollow propeller shaft to provide a direct passage for the crankcase vapors to the atmosphere. Refer to paragraph 5.*i.* of this section for further information. On these engines, the crankcase breather outlet is blanked off with a crankcase breather substituting cover.

19. LUBRICATION.

a. GENERAL.—The lubrication system is of the full pressure dry sump type, in which all moving parts are under oil pressure except the cylinder walls, piston pins, crankshaft roller and ball bearings, which are lubricated by splash. The Limits and Lubrication Chart of AN 02-35-1 should be referred to, along with the description of the lubrication system outlined in this paragraph. Refer to Figure 30.

b. OIL PUMP.

(1) The oil is drawn from and returned to an external oil supply tank by an oil pump assembly mounted on the lower left side of the supercharger rear cover. The pump consists of a cast aluminum alloy body with cored passages for two sections accommodating separate pressure and scavenge pumps located at the rear and front of the pump body, respectively. Refer to Figure 31. Both pumps consist of two spur gears with large teeth, the scavenge pump gears being longer than those of the pressure pump. The drive is effected through a shaft milled with scavenge gear teeth and splined at both ends. This shaft is located in the approximate center of the gear section with the front end extending through an end plate to mesh with the oil pump drive in the rear supercharger housing cover by means of a splined coupling. The pressure pump drive gear, located at the rear of the body, is splined to the rear end of the oil pump drive shaft. A mating idler gear meshes with each of the drive gears of both the pressure and scavenge pumps. Covers at each end of the pump body retain and support the gears. Short hollow steel dowels align the end plates to the body. The front end plate is drilled with two large diameter holes

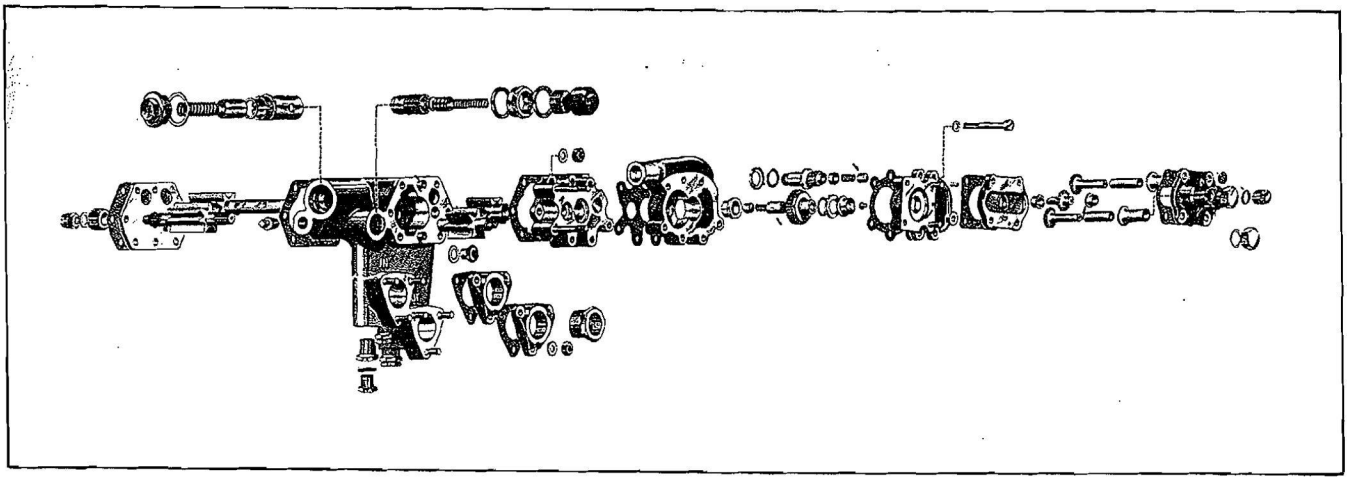

Figure 31—Oil Pump Assembly with Provision for External Oil Scavenge Line

which line up with similar holes in the supercharger rear housing cover to form the inlet and outlet passages for the oil pump. Provision is made for the flanged inlet and outlet connections with the outlet slightly below the inlet for accessibility. Two oil inlet and one oil outlet temperature connections are also provided. Two spring-loaded valves located in the outlet passage of the pressure pump are treated in subsequent paragraphs.

(2) Oil enters the left-hand pump connection, passes up through the cored inlet passage, enters the pressure pump gears at the bottom, is carried around in the spaces between the gear teeth, and is discharged into a pocket-shaped chamber at the top of the gears. Refer to Figure 32. From this pocket the oil has two possible outlets, both of which are controlled by spring-loaded piston type relief valves.

(3) THE OIL INLET CHECK VALVE.—All oil entering the engine must pass through this valve. The spring tension, which is not adjustable, is designed to keep the valve closed against the gravity head of oil in the supply tank when the engine is stopped, and to open with very little restriction when the engine is running. The valve assembly is retained in a bronze sleeve which is screwed into the oil pump body, and over which a steel cap is screwed. The alloy steel piston is spring-loaded and accommodates one bronze piston ring. When the engine is running, end movement of the piston uncovers ports in the sleeve through which the oil passes to the engine. Displaced air and oil leakage is vented through a drilled passage into the supercharger rear housing cover and housing. An oil pump check valve was replaced with a substituting plug in some of the Model R-1820-40, -40B, -54, -60, and -87 engines.

(4) THE OIL PRESSURE RELIEF VALVE.—This valve is incorporated in the oil inlet to provide a means of pressure regulation.. The piston type pressure relief valve consists of a bronze alloy body containing a nickle steel piston with a flat seat. A steel lock nut and a steel cap screwed on the outside diameter of the adjusting screw, keeps the screw from loosening, and prevents oil leakage. The bronze retaining body is screwed into the oil pump body. When the oil pressure in the pocket-shaped chamber of the oil pump body exceeds the spring tension, set by regulation of the adjusting screw, the piston slides back and uncovers ports in the bronze body through which excess oil by-passes into the cored oil inlet passage at the entrance to the pressure pump gears. Turning the adjusting screw in a clockwise direction increases the spring tension and the engine oil pressure. Anti-clockwise movement of the adjusting screw produces the opposite effect. Displaced air and oil leaking around the piston passes through a hole drilled in the adjusting screw into the dome of the retaining cap. The cap and lock nut have a groove milled lengthwise in their internal threads, through which the dome of the retaining cap is vented to the oil pump body, where a drilled passage discharges the displaced oil and air into the supercharger rear housing. Later production engines incorporate a ball-type pressure relief valve. This valve differs from the piston type in that a steel ball replaces the piston. A different valve body is used to provide a spherical seat for the ball valve. Refer to Figure 33.

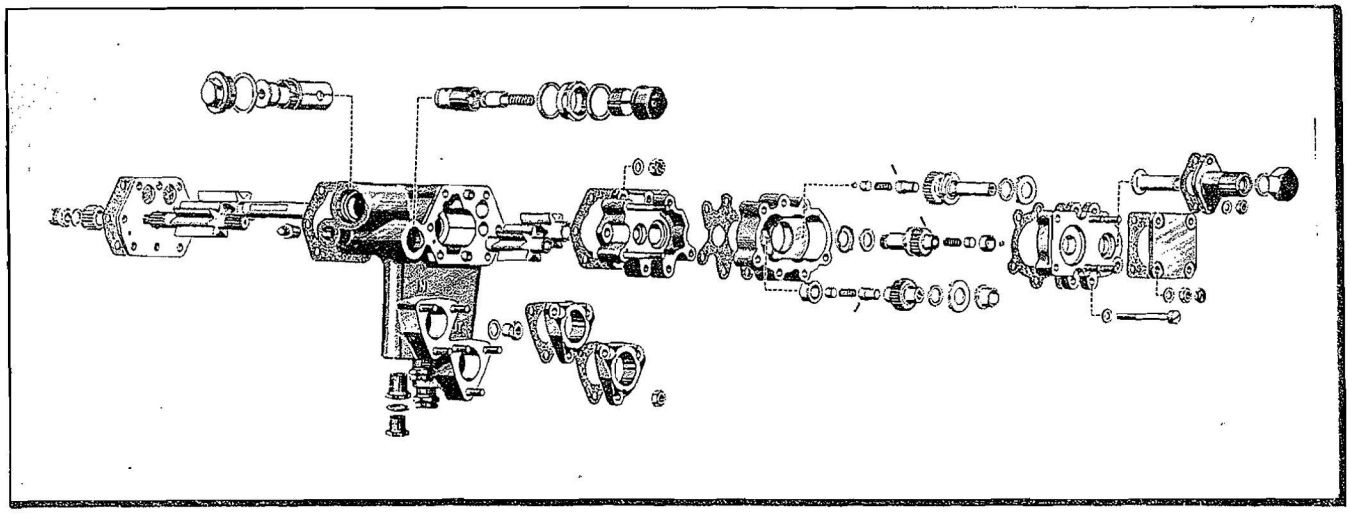

Figure 32—Oil Pump Assembly

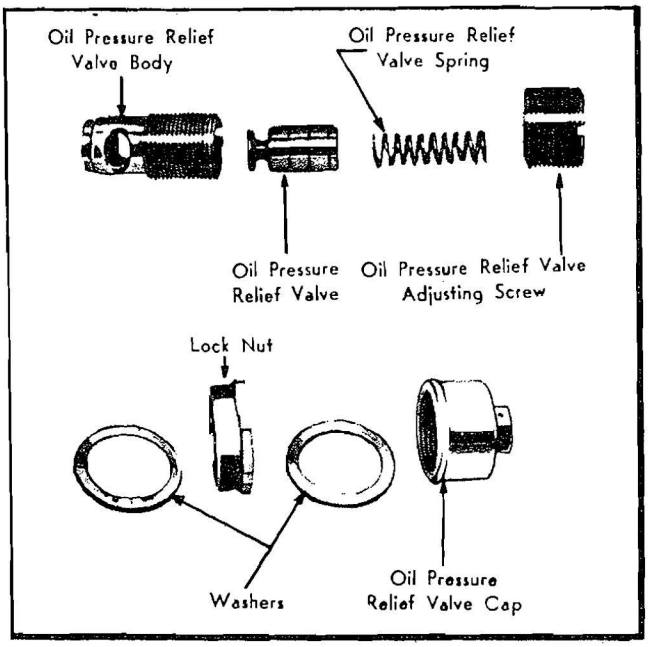

Figure 33—Oil Pressure Relief Valve

c. TWO TYPES OF STRAINERS

(1) THE CUNO AUTOMATIC FILTER.

(a) After leaving the oil pump the oil flows through a hole drilled in the supercharger rear cover. Passing through the rear cover, the oil fills an annular chamber surrounding the Cuno automatic filter.

(b) The filter consists of a cartridge filter unit made up of closely spaced disks separated by cleaner blades, and a small hydraulic motor to provide continuous rotation of the cartridge. Refer to Figure 34. The cleaner blades remain stationary and impart a combing action to the disks which turn at approximately one to two rpm under normal operating conditions. The motor operates on a very little amount of the filtered oil, is self-starting, and remains in operation as long as the lubrication system is under pressure. The oil used by the motor returns to the engine lubricating system. A pinion shaft is provided to turn the cartridge manually for inspection or test purposes. A spring-loaded ball pressure relief valve is incorporated in the filter to allow the oil to by-pass the oil filter in the event the oil is cold and viscous or the unit becomes clogged.

(c) The inner end of the filter cartridge is a light press fit in the accessory drive and starter shaft supporting boss of the supercharger rear housing. The oil is forced into the hollow center of the filter either through the closely spaced disks or through the pressure relief valve, where it is conducted to the inner end of the filter, and through an annulus surrounding the bronze accessory drive and starter shaft supporting bushing. At this point the oil is subject to its first division, with the major quantity of oil continuing through the engine, and the remainder lubricating the accessory drives in the supercharger rear housing cover.

(2) PRESSURE OIL STRAINER

(a) The pressure oil strainer is located in a cored chamber in the front face of the supercharger rear housing cover. A rubber packing ring in a groove near the mouth of this chamber surrounds the strainer housing and seals against oil leakage into the supercharger rear housing. Oil passing through the check valve enters the strainer cavity and passes through holes in the strainer housing and through the wire screen to the inside of the strainer.

(b) Should the strainer become clogged, or if the oil is too cold to flow freely, a spring loaded ball type valve is provided, allowing the oil to by-pass the strainer and continue lubricating the engine.

d. SUPERCHARGER REAR HOUSING COVER LUBRICATION.

(1) The front face of the rear cover is cast with four ribbed sections extending radially from the accessory drive and starter shaft supporting boss. These ribbed sections are drilled to conduct the oil to the accessory drive bushings from the annulus around the accessory drive and starter shaft. A tube extending from the top of the accessory drive and starter shaft supporting boss conducts oil to a pressure gage connection at the upper right-hand section of the cover.

(2) The two upper drilled ribbed sections supply oil to a groove around the outside circumference of each magneto shaft bushing. The upper portion of each magneto shaft bushing is milled away for the installation of the gun synchronizer supports. The milled-away portions uncover the oil grooves of the magneto shaft bushing in two locations, through which oil issues to lubricate the gun synchronizers and the

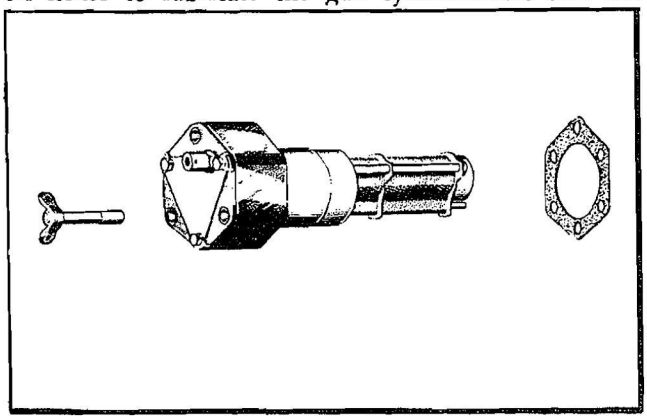

Figure 34—Cuno Oil Filter

inside circumference of the magneto shaft bushings. The inner gun synchronizer support bushing is provided with grooves in its inside diameter, through which oil enters the support to lubricate the outer bushing and the synchronizer mechanism. Holes drilled in the outer flanged section of the gun synchronizer support drain the surplus oil into the supercharger rear housing.

(3) The lower right-hand drilled passage provides oil to a groove around the outside circumference of the accessory drive bushing. This bushing is milled away in a similar manner to the magneto bushings, to accommodate the fuel pump support and uncovering the oil groove at two points. Oil issuing out of the two openings supplies lubrication to the inside circumference of the accessory drive bushing and enters the fuel pump drive shaft support through grooves cut in the inside circumference of the inner shaft supporting bushing. The oil fills the support and lubricates the outer shaft supporting bushing. Surplus oil is drained back into the supercharger rear housing through holes drilled in the support near its outer flange. A passage is drilled angularly through the supercharger rear housing cover from rear to front at the accessory drive mounting pad, communicating with an oil groove opening at the accessory drive shaft bushing. Oil under pressure travels through this passage to lubricate the dual accessory drive gear box and accessories requiring engine oil for lubrication. A complete description of the dual accessory drive housing lubrication is found in this section.

(4) Oil from the lower left-hand drilled pressure passage enters the inside of the oil pump shaft bushing through a hole drilled in a groove extending around the outside circumference of the bushing at its front end. A longitudinal groove in the inside circumference of the bushing distributes the oil along its length. A circumferential groove and drilled hole are provided at both ends of the bushing so it cannot be installed incorrectly.

(5) A ribbed section between the oil pump drive shaft supporting boss and the generator drive shaft supporting boss forms an integral part of the front face of the supercharger rear housing cover casting. A branch passage is drilled through this section intersecting the oil pressure passage to the oil pump drive shaft bushing. Oil is supplied to a groove in the outside circumference of the generator shaft bushing through this branch passage. The groove is drilled with holes to lubricate the inside of the bushing. The supercharger rear housing cover is drilled from rear to front at the left-hand side of the generator mounting pad to communicate with the branch oil pressure passage for supplying the generator, or accessory, with engine oil if desired.

(6) The accessory drive gears run in a bath of oil which is constantly being forced out the ends of their shaft supporting bushings. To prevent the external leakage of oil, the following types of oil seals are employed:

Accessory Drive	*Seal Type*
Starter and Accessory Drive Shaft	Spherical oil seal ring of oilite material
Generator and Magneto Drives	Spring-loaded neoprene diaphragm
Fuel Pump Drive Shaft	Leather seal reinforced with coil spring
Tachometer Drives	Plunger loaded neoprene packing rings

(7) The supercharger rear housing cover is drilled at the base of a recess behind each accessory drive shaft bushing to drain the surplus oil into the supercharger rear housing. The magneto, oil pump, and spare drive shaft recesses have one drain hole each. The generator drive shaft recess has three drain holes, while the accessory drive and starter shaft recess has two internal drain holes and provision for one external drain at the lower right-hand side of the mount pad.

e. CRANKSHAFT AND CYLINDER LUBRICATION.

(1) The major quantity of oil arriving at the accessory drive and starter shaft bushing annulus passes through slots in the bushing and enters the hollow accessory drive and starter shaft through holes in its rear journal and holes in the hollow aluminum oil seal spacer. Some oil is forced into the inside diameter of the slotted accessory drive and starter shaft bushing, and is distributed over the front face of the bushing shoulder by shallow grooves. In passing through the accessory drive and starter shaft, some of the oil is forced through a hole drilled in the shaft near its front end and fills the annulus formed between the accessory drive and starter shaft and the impeller drive shaft. Oil flats are provided on the accessory drive and starter shaft outer diameter to distribute oil over the entire length of each impeller shaft supporting bushing. From the accessory drive and starter shaft the oil enters a recess in the rear counterweight crankcheek.

(2) A hole drilled through the rear crankcheek and into the crankpin conducts the oil into the center of the hollow crankpin. On recent engines two tubes extending into the hollow crankpin conduct some of the oil to flats milled on the crankpin. Refer to Figure 35. The flats distribute oil over the surface of the crankpin for the master rod bearing to ride on. The oil enters an annulus in the knuckle pin lock plate and is

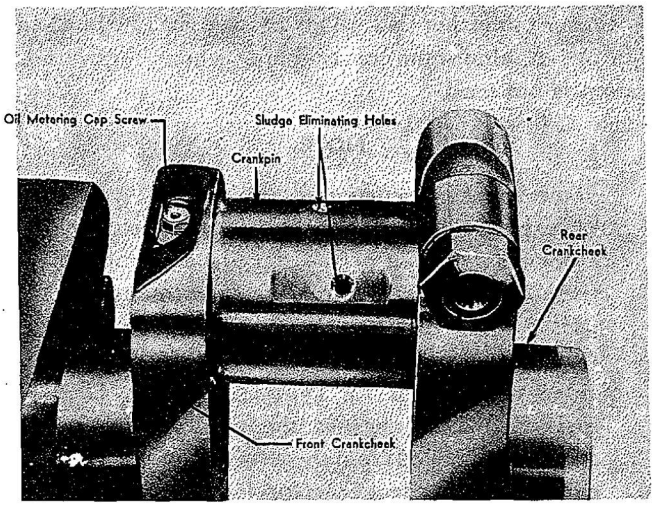

Figure 35—Crankshaft Sludge Eliminating Holes and Oil Metering Cap Screw

conducted through holes drilled in the knuckle pin lock plate tabs to the knuckle pin locking screws. The oil enters holes drilled in the front of the knuckle pin locking screws and fills the hollow centers of the knuckle pins. Two holes drilled 180° apart in each knuckle pin conduct the oil to the outside of the pin, where two flats distribute the oil over the knuckle pin bushings in the articulated rods.

(3) In some early engines a passage is drilled through the top center of the crankpin at its rear end to supply adequate lubrication for the cylinder walls, piston pins, and roller bearings. Oil is conducted through drilled passages in the rear crankcheek from the recess at the rear of the crankcheek to an annulus surrounding the floating damper pin bushings. An oil jet screwed into the front end of the crankpin also supplies lubrication for the cylinder walls, piston pins, and roller bearings. The motion of the crankshaft and connecting rods assures effective splash distribution.

(4) The oil is led from the crankpin through a drilled passage in the front crankcheek to the hollow drive shaft. Here it acts as a header for various indexing passages through which the cam and valve operating mechanism and the reduction gear assembly are lubricated. This reservoir also supplies oil to the propeller governor. In engines which incorporate crankshaft breathing, this oil reservoir is located in the annulus formed between the breather tube and the drive shaft.

f. REDUCTION GEAR LUBRICATION.

(1) From the reservoir in the hollow crankshaft the oil takes the following paths:

(a) Through a hole drilled in the wall section of the crankshaft to a hole drilled through the wall section of the propeller shaft to supply oil to the propeller governor pump and lubricate the reduction gear.

(b) Around the front end of the crankshaft to lubricate the propeller shaft front bushing by means of a flat on the surface of the crankshaft.

(c) Through an adapter into a distributor valve to supply hydro low pressure oil for operating a hydromatic propeller. Note that if an electric or test propeller is used, this passage is blanked off.

(d) The oil is distributed over the inside diameter of the propeller shaft rear supporting bushing by a flat on the surface of the crankshaft. Oil escaping out of the front end of the bushing travels along the crankshaft outside diameter in the annular space between the crankshaft and the propeller shaft internal sleeve to join the oil following the path described in *b.* above, thus keeping both propeller shaft supporting bushings under pressure lubrication.

(e) The major quantity of oil described in *a.* above, enters a circumferential groove on the inside diameter of the propeller shaft rear supporting bushing. Two oil systems originate at this groove, the first of which supplies oil for the propeller governor and the second for the reduction gear assemblies.

1. The lubrication of the propeller governor is described in paragraph 19.*b.*(1) of this section.

(2) Lubrication of the R-1820-65 and -97—.5625 (16:9) ratio reduction gearing is as follows:

(a) Oil is supplied to longitudinal grooves on the outside diameter of the propeller shaft rear supporting bushing through radially drilled holes equally spaced around the bushing. The oil flows back along the longitudinal grooves into a circumferential groove on the outside diameter of the bushing. This groove lines up with the drilled passages in the propeller shaft pinion supporting flange to conduct the oil to an annulus formed between the rim of the flange and the attached pinion carrier ring. From this annulus the oil enters the annular spaces around the twenty necked pinion retaining bolts through twenty drilled holes in the carrier ring. The oil is fed to the floating pinion bushings by two radially drilled passages in each pinion supporting trunnion. The passages are 90° apart facing the leading side of each trunnion and are interconnected by a cir-

cumferential groove. The floating pinion supporting bushings are drilled with six holes to supply ample lubrication to both sides of the bushing. Surplus oil escaping from the ends of the bushing provides a bath of oil for the planetary reduction gear teeth.

(3) Lubrication of the R-1820-40, -40B, -60, -71, -73, and -87-.666 (3:2) reduction gearing is as follows:

(a) The oil is supplied to longitudinal grooves on the propeller shaft rear supporting bushing in a similar manner as described in paragraph (2) *(a)* above; however, from the circumferential groove on the outside diameter of the propeller shaft rear supporting bushing, the oil is led to a hole drilled in each of the six spider arms on the propeller shaft. The oil is fed through these passages into a groove in each spider arm bushing. From these grooves the oil passes through drilled holes in the pinions into the annulus formed between the inside diameter of the pinion and the lock nut. Another drilled hole leads the oil from this annulus back to the bushing in the spider arm.

g. CAM AND CAM DRIVE GEAR LUBRICATION.

(1) A second drilled passage in the crankshaft at the reduction driving gear spacer forms a second oil system which lubricates the cam and cam drive mechanism.

(2) The oil is conducted from the crankshaft to the spacer through six drilled passages in the spacer. These six drilled passages communicate with an annulus in the front main roller bearing retainer ring. These holes drilled in the cam bearing hub connect the oil from the annulus to lubricate the cam hub bearing.

(3) A drilled passage in the cam drive and pinion gear bracket intersects the passage leading oil to the cam hub bearing, and supplies lubrication to the cam drive and pinion gear bushing through a hole drilled in the bushing and a flap on the cam drive and pinion gear shaft. Leakage from the bushing supplies lubrication for the cam gear teeth and the cam follower rollers.

h. VALVE GEAR LUBRICATION.

(1) Oil to the propeller governor pump originates in the passages described in paragraph 19.*f.* of this section. The oil passes through a drilled passage in the stationary reduction gear and through indexing passages in the crankcase front section to the governor mounting pad. This passage may be blocked off by an aluminum cover plate when a governor pump is not used.

NOTE

Some engines incorporate an external hydro oil supply line, or provision for one, leading from the left side of the starter pad, around the edge of the rear cover and between cylinders No. 7 and 8, to a tapped hole in the crankcase front section adjacent to the intake valve tappet boss for cylinder No. 7. On early R-1820-97 engines the external hydro oil supply line led from the left-hand gun synchronizer impulse generator location on the supercharger rear housing, through the intercylinder air deflector between cylinders No. 8 and 9, to the low pressure governor oil supply passage in the crankcase front section. This line provides additional oil and pressure to the propeller governor pump.

(2) A passage intersecting the low pressure governor pump oil supply passage conducts the oil to an annulus surrounding the governor drive bushing, lubricating the bushing.

(3) A drilled passage intersecting the annulus around the governor drive shaft bushing connects with a channel machined into the shoulder of the rear surface of the crankcase front section. This channel is sealed by a rubber oil seal ring between the crankcase front main section and the crankcase front section.

(4) Drilled passages leading from the channel section supply oil to the eight valve tappet assemblies above the horizontal center line of the engine. Lubrication of the intake valve tappet assemblies on cylinder Nos. 1, 2, 8, and 9, and exhaust valve tappet assemblies on cylinder Nos. 1, 2, 3, and 9 will be accomplished as follows:

(a) Oil is metered into the hollow valve tappet every time a drilled hole in the reciprocating tappet coincides with the hole in the valve tappet guide which occurs when the cam roller is on the cam lobe. Surplus oil lubricates the inside diameter of the guide, tappet roller, hub, pin, and cam lobes.

(b) The oil is forced into the hollow push rods through indexing holes in the inner ball ends and the spring-loaded valve tappet socket.

(c) The oil enters the valve clearance adjusting screw through indexing holes in the push rod outer ball ends and the socket end of the adjusting screw.

The screw is drilled with three radial passages intersecting the index hole in the cup end of the adjusting screw, through which oil is delivered to a groove in the rocker arm threads.

(d) From the groove, the oil is forced through a drilled passage in the rocker arm through an annulus formed by the outer race retaining clip in the tapered roller bearing. Oil lubricates the bearing and escapes out its ends to supply lubrication to the rocker roller and valve stem.

(e) Excess oil from the upper rocker boxes drains down the inside of the push rod housing and is returned to the engine crankcase through an angularly drilled passage in the valve tappet guide which aligns with a spot-faced corner of the tappet roller slot in the crankcase.

(f) The following rocker assemblies are lubricated by pressure oil feed:

Cylinders No. 1, 2, and 9, both intake and exhaust; Cylinder No. 3-exhaust; Cylinder No. 8-intake.

(g) The rocker assemblies below the horizontal engine center line are lubricated by oil seeping through the clearance between each valve tappet and its guide, after which it runs down the inside of the push rod housing and fills the rocker box. The desired quantity of gravity fed oil for this purpose is obtained by controlling the valve tappet diametrical clearance in their guides.

i. TWO-SPEED ROLLER CLUTCH LUBRICATION.

(1) The oil for lubricating the supercharger roller clutch drives is taken from the oil passage leading to the groove around the generator drive shaft bushing. This oil is conducted through a small drilled passage in the rear cover to an annulus around the supercharger control valve.

(2) From this point, some of the oil flows through a drilled passage to the annulus around the rear end of the intermediate impeller shaft rear bushing and through the hollow shaft. At the approximate center of the intermediate impeller shaft some of the oil flows through three drilled passages to lubricate the intermediate impeller drive gear bushing and journal. The remaining oil continues through the hollow shaft and out the front end to lubricate the front bushing and journal, and the bushing and journal of the impeller shaft drive gear. This oil is also led through drilled passages to lubricate the intermediate impeller drive pinion gears and bushings.

(3) The remaining lubricating oil that does not flow to the hollow intermediate impeller drive shaft from the annulus around the supercharger clutch oil control valve shaft, flows through another drilled passage to lubricate the intermediate impeller drive shaft rear bushing and journal.

(4) The oil for operating the high ratio supercharger clutch drive is also provided from the annulus around the supercharger clutch oil control valve sleeve. This pressure oil is obtained by moving the supercharger clutch oil control valve to the rearward or "out" position. This allows the engine pressure oil to flow around the annulus cut in the supercharger clutch control valve, to a drilled passage in the control valve sleeve, and through a mating drilled passage in the rear cover, to the chamber behind the high ratio supercharger clutch piston.

(5) When the supercharger clutch oil control valve is shifted back to the low ratio supercharger clutch drive position, it blanks off the pressure oil passages to the chamber behind the high ratio supercharger clutch piston, and opens oil drain passages through the valve and the rear cover, thus releasing the pressure oil in the chamber behind the high ratio supercharger clutch piston. This releases the supercharger clutch piston, disks, and plates with the aid of the impeller clutch release spring.

j. TWO-SPEED PLATE CLUTCH LUBRICATION.

(1) With the two-speed plate type supercharger drive, the control valve assembly, which supplies the oil for the operation and lubrication of the two-speed supercharger drive, receives its supply from a passage drilled in the supercharger rear housing cover to intersect the pressure oil passage adjacent to the oil pump drive shaft supporting boss. The oil is distributed from the control valve chamber to the two-speed clutch unit through drilled passages in the supercharger rear housing cover.

(2) The valve admits the lubricating oil to a groove in the intermediate impeller drive shaft bushing in the rear cover. The steel portion of the bushing is drilled with longitudinal passages to bring the oil forward to an annulus inside the bushing, where it is distributed by means of a flat on the shaft, and whence it enters the inside of the hollow shaft through a

drilled passage. A steel sleeve known as the oil distributor plug is pressed into the hollow shaft to separate the lubricating oil from the operating oil which is used to operate the high-speed ratio clutch.

(3) The intermediate impeller drive shaft is drilled to provide lubrication to each of the five pinion gear supporting journals as well as the journals which support the bell-shaped gear and the planetary sun gear. A longitudinal groove through this pressed-in oil distributor plug allows the lubricating oil to reach the front supporting bushing, where it is distributed by a flat in the journal of the impeller drive gear.

(4) Ample drainage facilities are provided to prevent any tendency of the lubricating oil to operate one clutch with the other one engaged.

k. DUAL ACCESSORY DRIVE LUBRICATION.

(1) The supercharger rear housing cover is drilled just above the accessory drive shaft to supply pressure for lubricating the dual accessory drive gear box, and accessories mounted thereon requiring engine oil for lubrication.

(2) When the dual accessory drive assembly is installed, two pipe plugs are removed from the supercharger rear cover and one plug from the dual accessory drive housing. Refer to the installation drawing. All the bushings in the accessory drive assembly are pressure fed, with the surplus oil providing a bath for the gears, after which it is drained into the supercharger rear housing through the unplugged hole in the dual accessory drive housing which indexes with one of the uncovered holes in the supercharger rear housing cover. Pressure oil passages are drilled in the dual accessory drive housing cover to supply accessories requiring engine oil for lubrication. The Engine Installation Drawing should be referred to for information on which plugs to remove for external drainage when using other types of oil.

(3) Engine oil under pressure enters the upper left hand side of the dual accessory drive housing through a drilled passage which indexes with the supply passage in the rear supercharger housing cover. This passage extends through the housing to the parting flange where an indexing hole in the dual accessory drive housing cover conducts the oil into the cover passages so that both housing and cover receive oil from the same source of supply.

(4) Ribbed sections of the dual accessory drive housing and cover are drilled to supply oil to the four bushings in each, but as the systems are slightly different, the housing and cover will be treated separately.

(a) In the housing, oil is conducted from the drilled supply passage through a short passage to an annulus around the copper-lead main drive gear front bushing in the upper left-hand corner. The bushing is lubricated through two drilled holes and the remainder of the oil is delivered to an annulus around the center copper-lead bushing. This bushing is lubricated through three holes and the remainder of the oil takes two paths, both of which terminate in an annulus around the two remaining bushings in the housing. The upper right-hand bushing is lubricated through two holes and the surplus oil drains through a drilled passage at the front end of the bushing. The lower oilite bushing needs no drilled holes because of its porous structure. Surplus oil is likewise drained through a drilled hole at its front end.

(b) In the dual accessory drive housing cover, oil is conducted from the drilled supply passage into an annulus around the main drive gear bushing in the upper left-hand corner. The bushing is lubricated through three holes and the remainder of the oil takes two paths: to an annulus around the upper right-hand spare drive bushing and an annulus around the central bushing. The upper right-hand bushing is of oilite material and needs no oil holes. The annulus around this bushing is intersected by a drilled passage for pressure feed to an accessory. The central bushing is lubricated through drilled holes and the remainder of the oil takes an irregular passage to an annulus around the lower accessory drive bushing. This passage is irregular because it is made up of two drilled legs, at the junction of which a hole is drilled to supply oil to an accessory. The lower accessory drive bushing is of undrilled oilite material.

(5) A cast magnesium adapter plate may be installed on the lower drive to accommodate an accessory with the same stud spacing as the upper drive. This is drilled with an oil passage which has a hole on its front face indexing with the accessory supply passage on the lower drive mount pad, and an outlet on its rear face at a corresponding location to the upper drive accessory supply passage.

l. SCAVENGE SYSTEM.

(1) All of the oil in the lubrication system drains into an oil sump located between No. 5 and 6 cylinders. Refer to Figure 36. The crankcase front section drains through a large hole in the section directly into the

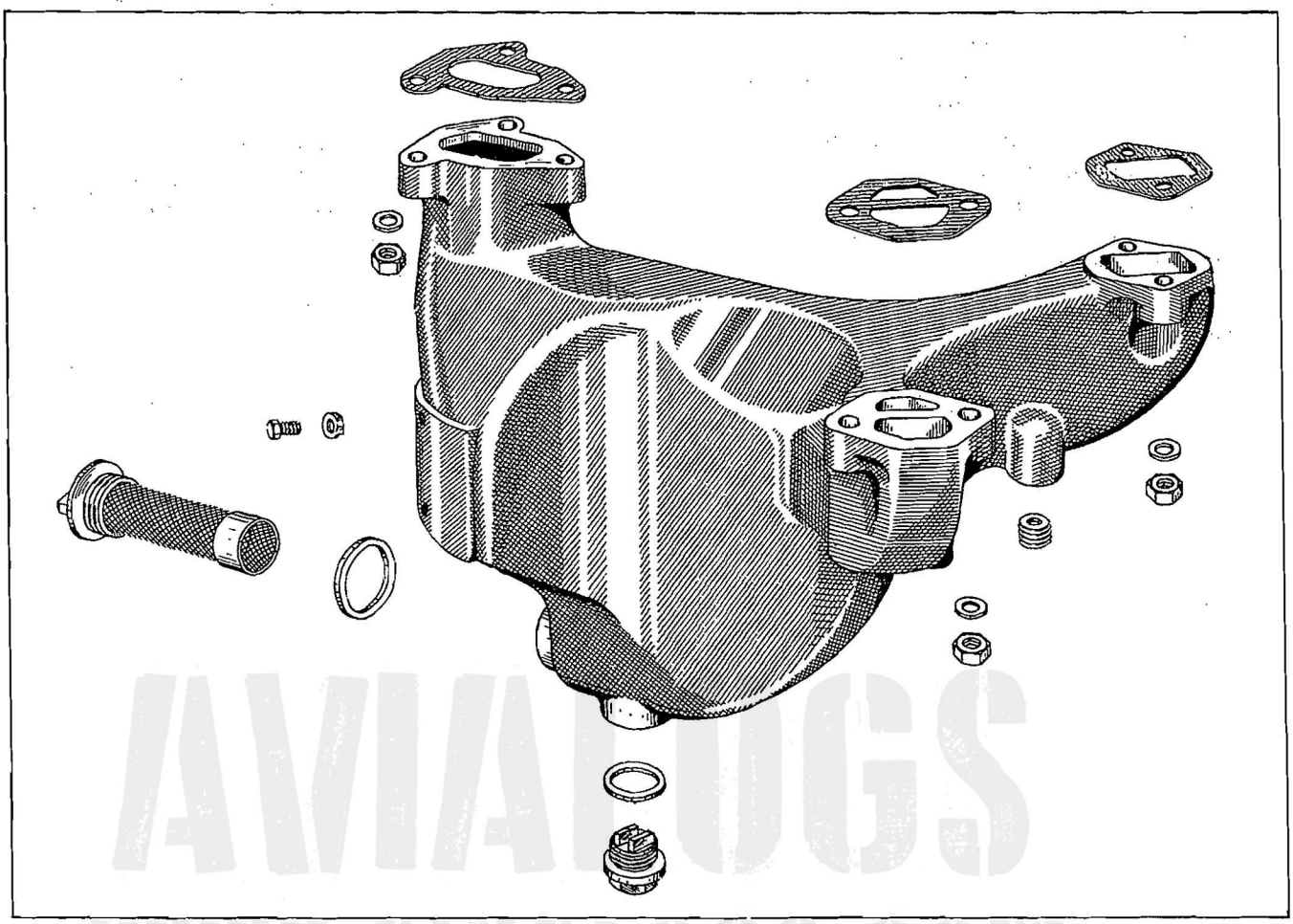

Figure 36—Oil Sump

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sump at its forward end. The crankcase main section drains into the flange channels in the main case. The front channel drains the oil into the crankcase front section through two short tubes in the front section, where it meets the front section drainage and passes into the sump. The rear channel in the crankcase main section drains into an escape outlet in the supercharger front section which drains into the left hole of the two large holes drilled in the left arm of the sump. Oil draining from the accessory gearing in the supercharger rear housing drains into the same hole in the supercharger front housing. The engine breathes through the hole in the right arm of the sump as described in paragraph 18 of this section.

(2) All oil being removed from the sump by the engine scavenge pump first passes through a removable cylindrical screen of twelve mesh per inch brass wire. The oil is then drawn by the scavenge pump through the large right hand hole of the left arm of the sump. This hole mates with a cored passage in the supercharger front and rear housings which connects with a drilled passage in the supercharger rear housing cover. A hole drilled in the oil pump body end plate lines up with the hole in the cover and delivers the oil to the scavenge pump gears which discharge into the external oil tank.

(3) Supplementing this scavenge system on current engines is an external oil scavenge line. The external oil line is connected to an adapter at the front of the sump oil strainer and is routed close to the engine crankcase to a vertical or horizontal scavenge oil inlet at the oil pump. Refer to Figure 31. The tube is clamped to the engine at several locations to prevent vibration. For a more complete description of this installation, refer to Sections IV and IX of this Handbook.

20. PRIMING SYSTEM.

a. To facilitate starting of engines equipped with

Bendix-Stromberg Injection Carburetors, it is necessary to provide a supply of fuel to the cylinders from some source other than the carburetor. This is accomplished by a priming system.

(1) FIVE-POINT PRIMING SYSTEM.—For engines equipped with five-point priming, attach the distributor to the clamp and place the clamp on the No. 1 cylinder intake pipe facing the rear, and at a location 8 inches from the center of the distributor to intake pipe packing nut. Do not tighten the clamp at this time. Place each priming tube in its approximate location and by placing No. 3 priming tube in one of the upper locations, slip the clamp over the intake pipe, install the nuts and bolts, but do not tighten. Screw on the union nuts at the intake ports and the distributor. Tighten each union at the intake port and distributor locations. Have the lower priming tube clamp set so as to have the tightening screw on the forward side. (See figure 242.) Tighten all clamp nuts.

(2) TWO-POINT PRIMING SYSTEM.

(*a*) The fuel is taken by an electric solenoid operated priming valve mounted on the carburetor fuel pressure regulator unit and discharged into the induc-

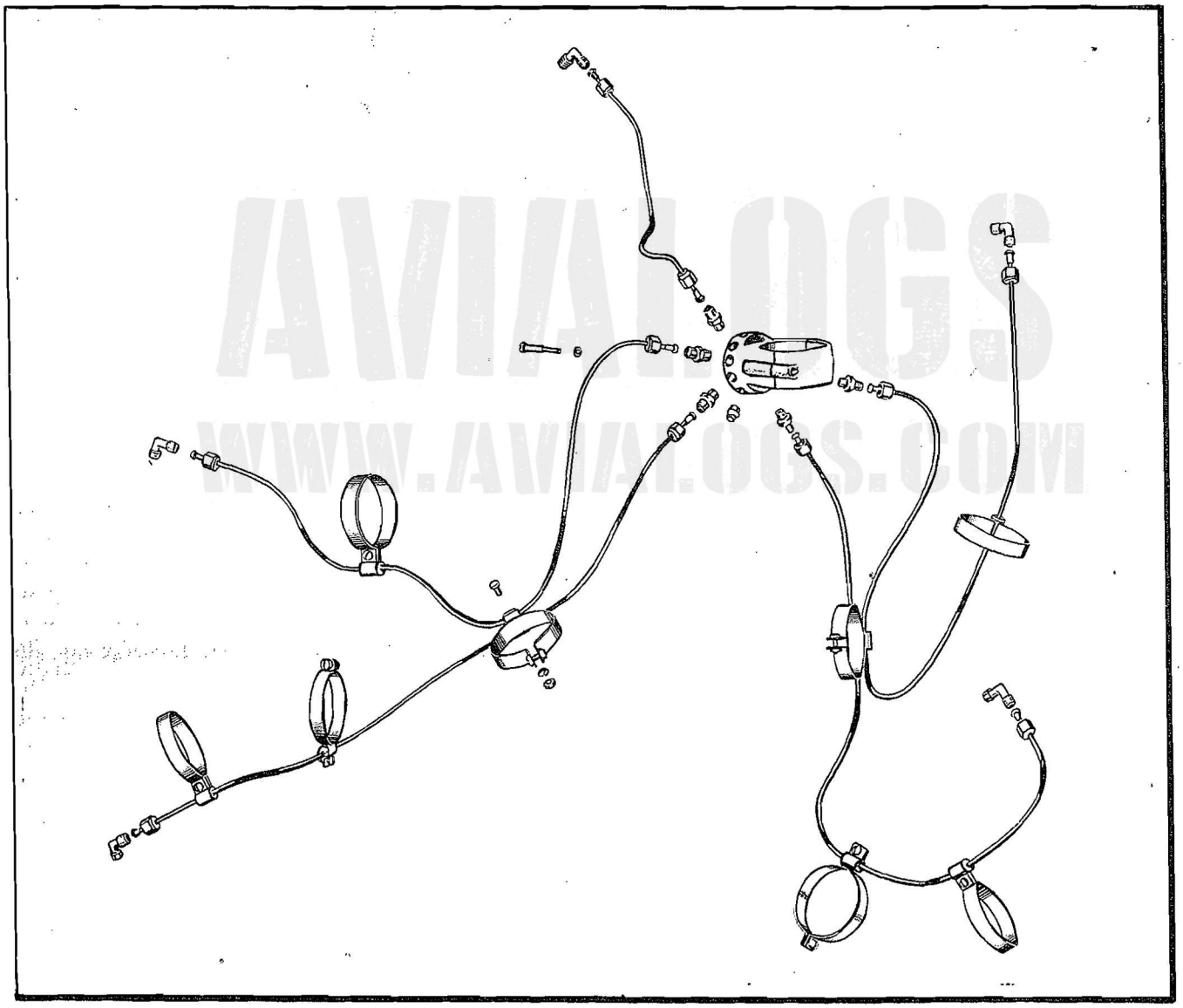

Figure 37—Five Point Priming

tion system through two feeder tubes, one on each side of the carburetor adapter. These tubes emanate from a "T" fitting on the carburetor primer valve and run to two primer discharge nozzles installed on each side of the carburetor adapter. Refer to Figure 38. A clip at about the midpoint of each tube secures it to the carburetor. The atomized charge is thus directed into the diffuser passage.

(b) Refer to AAF T. O. No. 02-1-29 or BuAer Manual, for operation of the primer.

(3) ONE-POINT PRIMING.—One-point priming on R-1820-40B engines is accomplished by means of a priming nipple installed in the flat of the supercharger front housing rear parting surface directly behind No. 8 intake pipe boss.

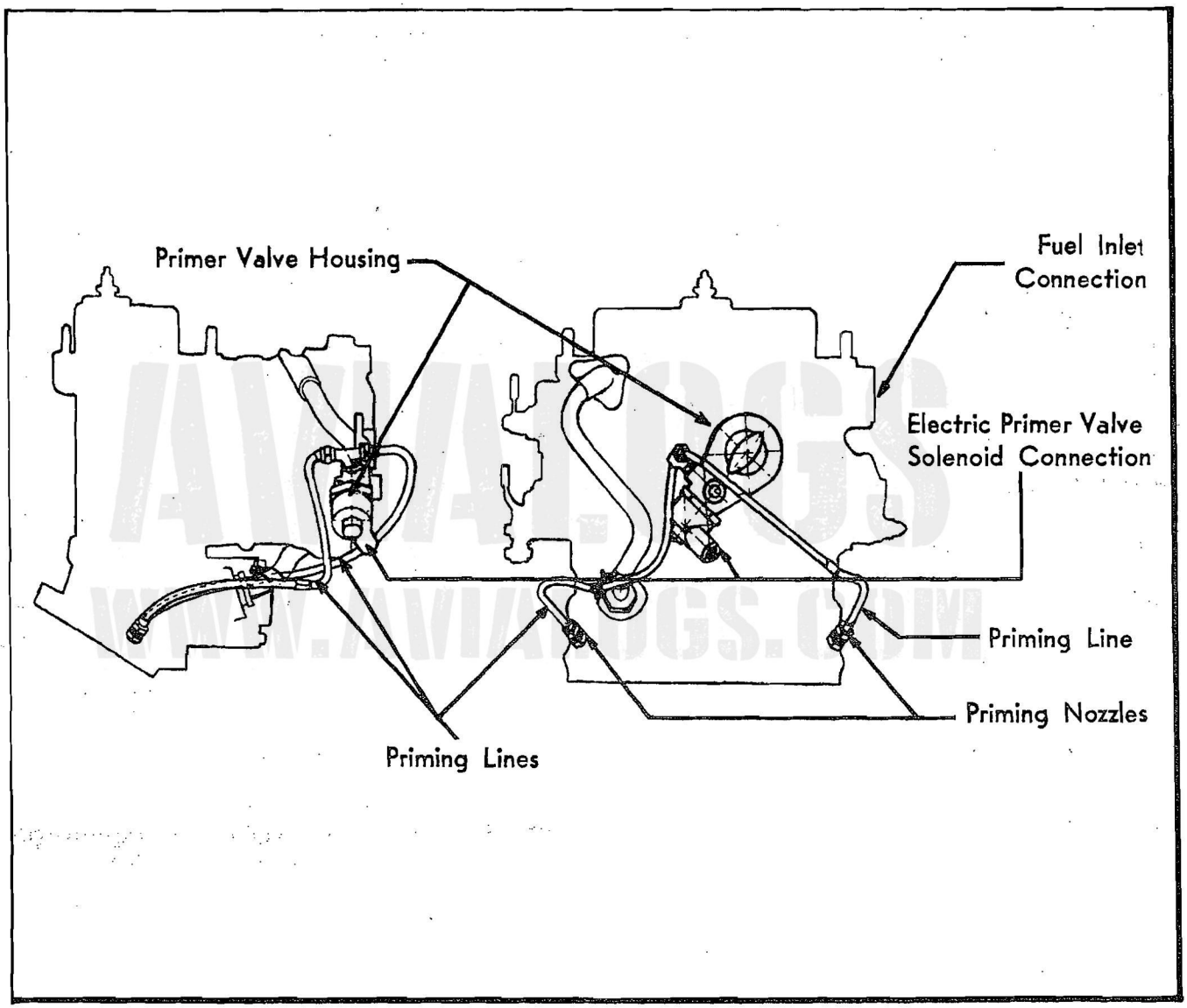

Figure 38—Two Point Priming

SECTION III
OVERHAUL TOOLS

1. DISASSEMBLY AND REASSEMBLY

Number *Name*

a. CRANKCASE TOOLS.

803262 Cleaning Tool—Supercharger front housing intake pipe packing nut thd.
800907 Cover—Intake pipe packing nut
83761 Eye—Prop. shaft and engine hoist, No. 50 spline
83863 Eye—Supercharger rear housing and cover hoist
83679 Plate—Engine floor stand
800687 Pliers—Push rod housing hose clamp, removing and installing
83596 Protector—Crankcase cylinder hole
801789 Protector—Crankcase main sections
82683 Puller—Crankcase section front main bearing and reduction drive gear multi-purpose removing
83648 Pullers—Crankcase sections removing
800213 Removing and Installing Tool—Supercharger front housing breather relief valve
801185 Screw Driver—Crankcase front section gov. oil line headless pipe plug
801184 Screw Driver—Crankcase front section gov. oil line headless pipe plug tee handle
84329 Sling—Engine hoist
900130 Stand Assy.—Eng. dissy. and assy., floor
83678 Stand—Engine disassembly and reassembly
83186 Stand—Engine parts, floor
802729 Stand—Engine parts holding (wooden) floor
801793 Stand—Supercharger rear cover and housing and two-stage intermediate housing, disassembling and studding
803295 Suction—Testing tools
84356 Wrench—Crankcase front main section to crankcase rear main section, bolt and nut, box 5/8 in. hex.
84949 Wrench—Crankcase front main section to rear main section bolt nut, box 5/8 in. hex.
802775 Wrench—Diffuser plate supercharger rear housing attaching nut 7/16 in.
800544 Wrench—Engine test mounting plate to disassembly and reassembly floor stand bolt box, 1¼ in. and 1½ in. hex.
82058 Wrench—Oil sump strainer, lug

Number *Name*

803146 Wrench—Oil sump strainer external oil tube connection (O.E. 1⅝ in.)
803152 Wrench—External oil tube adapter plug, socket, 1⅜ in. hex.
802901 Wrench—Reduction gear pinion carrier retaining nut, box ⅝ in. hex. Also used for crankcase front section and supercharger front housing to crankcase main screw. Part Nos. 2045-D-14-21-22 for model C9GC
83718 Wrench—Supercharger drain valve body
83381 Wrench—Supercharger rear cover to rear supercharger housing slotted round nut, lug
800315 Wrench—Timing hole plug oil sump drain plug, combination box and open-end, ¾ in. and ⅞ in. hex.

b. OIL PUMP TOOLS.

84664 Handle—Socket wrench, tee, ½ sq. (Used with wrenches 84217, 84662 and 84663)
84682 Removing and Installing Tools—Oil pump idler gear shaft
800390 Wrench—Oil pressure relief valve body and adjusting screw lock nut, open end 1 in. and 1⅛ in. hex.
803372 Wrench—Oil pressure relief valve body, lug
801999 Wrench—Oil pressure relief valve nut adjusting socket, 1⅜ in. hex.
82676 Wrench—Oil pump coupling and magneto coupling (17 teeth)
800684 Wrench—Oil pump foot to supercharger rear cover nut, box, ⅝ in. hex.
800808 Wrench—Oil pump to supercharger rear cover nut, box, ½ in. hex.
84708 Wrench—Oil temperature gage and carburetor adapter temperature bulb connections bushing, socket ⅞ in. hex.
84663 Wrench—Oil temeprature gage and carburetor adapter temperature bulb connections plug, socket 13/16 in. hex.
84504 Wrench and Screwdriver—Oil pressure relief valve nut adjusting socket

c. CAM AND CAM DRIVE TOOLS.

803310 Holding Tool—Cam drive gear bolt head

Number	*Name*
800993	Installing Tool—Cam bearing ring
84535	Pullers—Cam bearing ring, removing
83657	Puller—Cam bearing ring, vacuum pump upper drive coupling and generator drive oil seal screw reinforcing plate removing

d. IMPELLER AND IMPELLER DRIVE TOOLS.

84534	Adapter—Impeller locking tool
803640	Adapter—Impeller shaft retainer centering
800096	Fixture—Magneto and gun synchronizer drive gear shaft assembly vise
84657	Fixture—Tachometer fuel pump and dual accessory drive gear and shaft assembly vise
800232	Installing Tool—Generator drive oil seal collar. (Used with puller 801645)
800231	Installing Tool—Magneto drive oil seal collar

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Number	*Name*
801420	Adapter—Propeller shaft thrust ball bearing rear inner race removing puller. (Used with 800377)
800378	Adapter—Propeller shaft thrust ball bearing removing puller. (Used with 800377)
803250	Adapter—Propeller shaft thrust bearing spacer removing puller hydraulic jack and pump
84858	Adapter—Reduction driving gear removing puller 84857
801661	Adapter—Reduction drive gear 20 ton hydraulic removing puller
82197	Arbor—Propeller hub rear centering ring to propeller hub lapping. Used for engines equipped with No. 50 propeller hub spline
80443	Bar—Crankshaft aligning (.6254 in. dia. selective fit #1)
83576	Bar—Crankshaft aligning (.6248 in. dia. selective fit #2)
83577	Bar—Crankshaft aligning (.6250 in. dia. selective fit #3)
800735	Bending Tool—Reduction gear drive pinion lock nut cotter pin 45° vise
80198	Extension—Crankshaft cheek capscrew wrench 80309
802955	Eye—Crankshaft to disassembly and assembly hoist
82151	Eye—Crankshaft hoist
83761	Eye—Propeller shaft and engine hoist
800710	Fixture—Crankshaft (Used with stand 800711)
801560	Fixture—Propeller shaft assembling
803529	Fixture—Propeller shaft holding bench
80292	Handle—Crankshaft and propeller shaft turning tool. (Used with 82666 and 83864)
800310	Installing Tool—Propeller shaft thrust bearing spacer heating
800991	Installing Tool—Reduction driving gear
84536	Installing Tool—Reduction driving gear spacer and ring. (Crankshaft oil seal spacer and ring assembly)
802922	Jack and Pump—Multi-purpose removing puller hydraulic hand (20 ton)
900026	Jack and Pump Assembly—Multi-purpose removing puller hydraulic, hand. (See used with note)
801363	Jack and Pump Assembly—Propeller shaft thrust bearing removing puller, hydraulic
803249	Jack and Pump—Propeller shaft thrust bearing removing puller, hydraulic
83308	Locking Tool—Reduction gear drive pinion. Used for 3:2 reduction gear engines except G-200 left hand rotation
82200	Measuring Tool—Crankshaft cheek capscrew stretch
83596	Plate—Master and articulated rod guide. (Used with stand 83586 and rollers 82658 in inspection). (Also listed in connecting rod)
83922	Protector—Propeller shaft thread No. 50 spline
801111	Puller—Accessory drive and starter shaft coupling removing
84512	Puller—Crankpin plug removing
800477	Puller—Crankpin plug removing
801845	Puller—Crankshaft breather hole plug removing
84562	Puller—Crankshaft front main bearing inner race removing
801508	Puller—Crankshaft main front roller bearing outer race
801752	Puller—Crankshaft main rear roller bearing outer race, removing
84559	Puller—Crankshaft rear main bearing inner race removing. Used with adapter 84561
800377	Puller—Propeller shaft thrust bearing removing. Used with adapters 800378 and 800420
801362	Puller—Propeller shaft thrust bearing spacer removing hydraulic
84857	Puller—Reduction driving gear removing
801208	Puller—Reduction drive gear 20 ton hydraulic removing
84765	Removing and Installing Tool—Crankshaft rear end
802694	Rollers—Crankshaft alignment checking
84699	Screw—Crankshaft rear end removing and installing tool. Used with removing and installing tool 84765
83586	Stand—Crankshaft alignment checking, floor
800711	Stand—Crankshaft floor fixture. (Used with fixture 800710)
802763	Stand—Propeller shaft holding fixture, floor

Number	*Name*
82666	Turning Tool—Crankshaft. (Used with handle 80292)
83864	Turning Tool—Crankshaft. (Used with handle 80292.) (24 reduction gear splines)
82284	Turning Tool—Propeller shaft
82195	Wrench—Crankshaft breather tube nut, plug 2-1/32 in. hex.
80309	Wrench—Crankshaft cheek capscrew box 1-9/16 in. hex. (Used with extension 80198)
80409	Wrench—Crankshaft rear main bearing retainer, nut, lug
82889	Wrench—Propeller shaft thrust ball bearing nut lug
82670	Wrench—Reduction drive gear nut, box 3-5/8 octagon
800562	Wrench—Reduction gear drive pinion lock nut, plug 9/16 in. hex. Used for 3:2 and 16:11 reduction geared C-14A engines. Used with extension 802119 and torque wrench 84922.
84217	Wrench—Standard reduction gear support to crankcase front section stud nut, socket, 9/16 in. hex. Used for the two 3/8 in.-24 slotted hex nuts on 3:2 or 16:11 reduction geared engines.

g. CONNECTING ROD TOOLS.

803475	Adapter—Knuckle pin locking plate impact removing puller. Used with 802242.
802593	Clamp—Master rod spacer side clearance checking
83913	Fixture—Knuckle pin removing and installing arbor press
83596	Plate—Master and articulator rod guide
800924	Protector—Master rod crankshaft bearing bore—Cleaning
800929	Protector—Master rod knuckle pin hole cleaning
802242	Puller—Impact multi-purpose. Used with 802343

h. CYLINDER INTAKE PIPE AND PISTON TOOLS.

801775	Adapter—Cylinder hold down nut and capscrew pneumatic speed wrench, 1/2 in. and 9/16 in. hex.
800197	Adapter—Piston pin retaining spring, installing tool
801506	Adapter—Piston pin retaining spring removing tool
80440	Clamp—Piston ring
803145	Clamp—Piston ring
800910	Cover—Cylinder exhaust port
800909	Cover—Cylinder intake port
801853	Driver—Cylinder hold down nut and capscrew pneumatic speed wrench, 1/2 in. and 9/16 in. hex.
802176	Gear—Cylinder hold down capscrew pneumatic speed wrench, replacement socket, 1/2 in. hex.
803121	Gear—Cylinder hold down nut and capscrew pneumatic speed wrench, 1/2 in. x 9/16 in. hex. Driving replacement
803122	Gear—Cylinder hold down nut and capscrew pneumatic speed wrench, 1/2 in. x 9/16 in. hex. intermediate replacement
83906	Installing Tool—Cylinder base thermocouple wire retainer bushing, staking
84861	Installing Tool—Piston pin retaining spring
801019	Installing Tool—Thermocouple wire bushing
800259	Protector—Cylinder head fin
802270	Protector—Piston and cylinder sand blasting rubber hose
802919	Puller—Exhaust valve spacer retainer, removing
804868	Removing Tool—Piston pin
84377	Removing Tool—Piston pin retainer spring
84770	Removing Tool—Rocker box cover washer, magnetic
802177	Screw—Cylinder to crankcase, locating, 1/2 in. hex.
802586	Stand—Cylinder holding
802788	Tank—Cylinder cleaning
803313	Tray—Cylinder hold down capscrew holding
802293	Wrench—Cylinder hold down capscrew, box, 1/2 in. hex.
802173	Wrench—Cylinder hold down capscrew pneumatic, speed, 1/2 in. hex.
83130	Wrench—Cylinder hold down nut and capscrew, speed, 1/2 in. hex.
84258	Wrench—Intake pipe packing nut, lug
80449	Wrench—Rocker box cover nut, socket, 7/16 in. hex.
84566	Wrench—Rocker box cover nut, socket speed, 7/16 in. hex.

Number	*Name*
82750	Wrench—Cylinder hold down nut offset box, 9/16 in. hex.
82860	Wrench—Cylinder hold down nut box, ½ in. hex.
83131	Wrench—Cylinder hold down nut, socket, speed 9/16 in. hex.

i. VALVE MECHANISM TOOLS.

802226	Adapter—Rocker arm hub bolt impact removing, puller
802726	Adapter—Valve tappet guide impact removing puller. (Used with puller 802242)
81409	Compressor—Valve spring
82354	Compressor—Valve spring
801895	Fixture and Plug—Rocker arm bearing
802512	Gage—Feeler (.010-.025-.075 in.) rocker arm roller to valve stem, clearance
83182	Installing Tool—Push rod housing rubber hose
83634	Installing Tool—Valve tappet
801558	Loosening Tool—Valve spring washer lock impact.
802242	Puller—Rocker arm hub bolt impact removing
82703	Removing Tool—Push rod
800087	Removing Tool—Valve tappet circlet
81132	Screw Driver—Valve clearance adjusting screw
80262	Stand—Valve removing and installing bench (B/P only—see 801812 for extensive use)
801812	Stand—Valve removing and installing bench (See 80262 for less expensive stand)
801122	Wrench—Push rod housing hose clamp socket, ¼ in. hex.
800060	Wrench—Rocker arm hub bolt nut, ⅞ in. hex.
83202	Wrench—Rocker arm hub bolt and nut, ⅞ in. hex. and ⅞ in. open end. (For holding bolt while tightening nut with 800060)
802581	Wrench—Valve clearance adjusting screw clamp screw. (Use with torque wrench 802178)

j. MAGNETO, SPARK PLUG, IGNITION WIRING AND TIMING TOOLS.

802239	Adapter—Spark plug shielded terminal elbow slushing hydraulic gun (Alemite) for elbow shaving ⅝ in.–24 threads in the knurled nut I.D.
800947	Adapter—Timing disk used with disk 801083
801652	Crimping Tool—Ignition wire ferrule
801083	Disk—Timing detail of 83517
84639	Gap and Form Tool—Spark plug electrode (B G)
802157	Gun—Spark plug—Shielded terminal elbow slushing, hydraulic (Alemite)
80932	Indicator—Top dead center
803388	Puller—Oil pump coupling and magneto coupling
803177	Screw Driver—Bosch & Scintilla magnetic block insulated wire, locking fillister head screws
803223	Stand—Wiring harness, revolving floor
803054	Timing Plug—Crankcase front section timing hole
800630	Wrench—Crowfoot, ignition wire spark plug terminal ¾ in. hex.
803198	Wrench—Ignition cable to spark plug elbow knurled fitting .785 in. O.D.
84673	Wrench—Ignition wiring harness conduit tube coupling, strap
803199	Wrench—Magneto conduit knurled fitting 1.750-1.775 in. O.D.
801182	Wrench—Magneto drain plug, socket 9/32 in. sq.
82676	Wrench—Magneto gear and oil pump drive shaft front gear (17 teeth)
84458	Wrench—Spark plug, socket, ⅞ in. hex. Army
84450	Wrench—Spark plug socket, ⅞ in. hex. Navy and Commercial

k. MISCELLANEOUS TOOLS.

803163	Adapter—Torque wrench (2x1200 in. lbs) detail of 802119
802781	Bench—Honing machine tools holding, wooden
802777	Bench—Wooden shop work
803203	Cleaning Tool—Stud threads ¼-28, 5/16-24, ⅜-24
803204	Die—Stud thread ¼-28 cleaning tool
803205	Die—Stud thread 5/16-24 cleaning tool
803206	Die—Stud thread ⅜-24 cleaning tool
802119	Extension—Torque wrench
803162	Extension—Torque wrench (2x1200 in. lbs) detail of 802119

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Number	*Name*
803119	Gun—Engine parts cleaning spray
81403	Handle—Wrench (7/16 in. dia.)
803118	Lighting System—Inspection bench
802242	Puller—Multi-purpose impact removing
800689	Screw Driver—Carburetor jet (Stromberg injection type)
803113	Stand—Small parts holding, wooden
802793	Tank—Large engine parts heating, oil
802896	Washing Machine—Engine parts rotary
800684	Wrench—Dual accessory drive housing and oil pump foot to supercharger rear cover nut, box 5/8 in. hex.
801080	Wrench—Generator attaching nut, 9/16 in. open end
83507	Wrench—Reduction gear pinion bolt, holding
84325	Wrench—Square head pipe plug open end 9/32 in. and 3/8 in.
801182	Wrench—Square socket, 9/32 in.
801183	Wrench—Square socket, 3/8 in.
803147	Wrench—Square socket, 7/16 in. sq.
801081	Wrench—Starter attaching nut, 9/16 in. hex., box
84654	Wrench—Starter attaching nut, 9/16 in. open end
802178	Wrench—Torque (300 in. lbs)
84922	Wrench—Torque (1200 in. lbs) pivot handle
802700	Wrench—Torque, double handle (6000 in. lbs)

2. INSPECTION.

a. ACCESSORY DRIVE TOOLS.

800258	Gage—Supercharger rear cover to accessory drive and starter shaft coupling flush pin
802243	Gage—Supercharger rear cover to accessory drive and starter shaft coupling flush pin

b. CRANKSHAFT TOOLS.

802694	Roller—Crankshaft alignment checking

c. CONNECTING ROD TOOLS.

83269	Gage—Knuckle pin bushing, maximum wear flat plug (1.193 in. dia.)
82043	Gage—Piston pin bushing maximum wear flat plug (1.05065 in. dia.)

Number	*Name*

d. CYLINDER, INTAKE PIPE AND PISTON TOOLS.

800470	Fixture—Rocker box cover air test, bench
802146	Fixture and Plugs—Cylinder air test, consists of details: 82044, 82306, 82447
800641	Gage—Cylinder bore
84757	Gage—Cylinder bore gage setting, master ring
800822	Gage—Cylinder hold down capscrew neck dia. snap
84995	Gage—Cylinder hold down capscrew thread max. wear ring
800124	Gage—Cylinder hold down cap screw thread max. wear ring
800125	Gage—Cylinder hold down cap screw thread max. wear ring
82664	Gage—Exhaust valve guide valve stem hole, flat plug
800574	Gage—Intake valve guide valve stem hole, flat plug
801365	Gasket—Cylinder air test fixture and plugs, exhaust port
801364	Plate—Cylinder air test fixture and plugs, exhaust port

e. VALVE MECHANISM TOOLS.

84970	Block—Valve tappet ball socket wear gage. (Used with 82880)
83950	Fixture—Rocker arm roller bearing end play and smoothness checking
802687	Gage—Exhaust valve bluing
802891	Gage—Exhaust valve stretch
800352	Gage—Intake valve
800503	Gage—Intake valve bluing
802527	Gage—Valve tappet guide limit plug

3. RECONDITIONING.

a. CRANKCASE TOOLS.

801530	Adapter—Supercharger front housing impeller shaft bearing support honing fixture
802201	Adapter—Supercharger front and rear housing sleeve and impeller shaft support sleeve honing and oil seal ring lapping tools
83907	Adapters—Supercharger rear cover bushing replacement fixture

Number	Name
802132	Adapter—Supercharger rear housing to carburetor adapter stud removing drill ream and tap jig (7/16 in.–14)
802133	Adapter—Supercharger rear housing to carburetor adapter stud removing drill, ream and tap jig (⅜ in.–16) and 7/16 in.–14 studs
800944	Adapter—Supercharger rear housing cover bushings removing, installing and finishing fixtures and tools
800955	Adapter—Supercharger rear housing cover bushings removing, installing and finishing fixtures and tools
84434	Adapter—Stud driver (⅜ in.–24)
803141	Adapter—Stud driver (½ in.–20)
84433	Adapter—Stud driver 5/16 in.–24. Used with driver 84431
84434	Adapter—Stud driver ⅜ in.–24. Used with driver 84431
84435	Adapter—Stud driver ⅜ in.–24. Used with driver 84432
84436	Adapter—Stud driver 7/16 in.–20. Used with driver 84432
800966	Adapter—Torque indicator booster pump drive gear bushing removing and installing tools
801704	Adapter—Prop. shaft bushings replacement fixture and tools
801203	Bar—Rear supercharger housing to rear supercharger housing sleeve shoulder face, gage
802781	Bench—Honing
801500	Boring Bar—Impeller drive gear shaft outer bushing or impeller drive multi-plate clutch gear bushing removing. Used with tool bit 800501 and fixtures 84854 and 800842
801499	Bushing—Impeller drive gear shaft outer bushing or impeller drive multi-plate clutch gear bushing blind end drill. Used with drill 801550
801503	Bushing—Impeller drive gear shaft outer bushing or impeller drive multi-plate clutch gear bushing removing and hand line reamer alignment. Used for engines equipped with "Thick Type" rear covers. Used with 84854 fixture and 801500 bar.
801243	Bushing—Rear supercharger housing carburetor adapter stud removing drill
801245	Bushing—Rear supercharger housing carburetor adapter stud removing drill, ream and tap
800066	Bushing—Supercharger rear housing drain valve extension tube removing, tapping, spinning and facing pilot
802699	Bushings—Impeller drive gear shaft outer bushing jig
800758	Collar—Supercharger front and rear housing impeller shaft sleeve removing and installing arbor press
82246	Cutter—Accessory drive gear shaft bushing (1.418)
84758	Cutter—Engine mounting bolt bushing. Hole (41/64 in. dia.) c'bore
83664	Cutter—Governor and torque ind. booster pump drive gear shaft bushing facing and chamfering drill press
82247	Cutter—Tachometer fuel pump mag. gun synch. and accessory drive gear shaft bushing 1.408
84882	Cutter—Reamer and plug sup. fr. ho. eng. mount. bolt bu. installing
801154	Drill—Cylinder hold down stud removing
84276	Drill—Cylinder hold down taper stud removing
84455	Drill—Extension 11/64 in. dia.
84277	Drill—Cylinder hold down taper stud, removing (¼ in. dia.)
801550	Drill—Impeller drive gear shaft outer bushing or impeller drive multi-plate clutch gear bushing blind end drilling and lockpin hole drilling extension ⅛ in. dia.
801498	Drill—Impeller drive gear shaft outer bushing or impeller drive multi-plate clutch gear bushing blind end removing 1.3125 in. dia.
83802	Drill—Impeller drive gear shaft outer bushing or impeller drive multi-plate clutch gear bushing lockpin hole, extension 1/16 in. dia. Used with jigs 800441, 800923 and 801550
801773	Drill—Supercharger rear cover generator pad oil hole plug 9/64 in. Used with 800714
800071	Drill—Supercharger rear housing drain valve extension tube, facing
800067	Drill—Supercharger rear housing drain valve extension tube, removing
800604	Drill—Supercharger front and rear housing.

Number	*Name*
	Imp. shaft sleeve pin head ring. Flat end 17/64 in. dia.
84431	Driver—Stud (5/16 in.–24 and ⅜ in.–24)
84430	Driver—Stud ¼ in.–28. (See 80402 for moderate use)
80442	Driver—Stud 7/16 in.–20. (See 84432 for extensive use)
80404	Driver—Stud ⅜ in.-24. (See 84431 and 84432 for extensive use)
80403	Driver—Stud 5/16 in.-24. (See 84431 for extensive use)
80402	Driver—Stud ¼ in.–28. (See 84430 for extensive use)
84431	Driver—Stud (5/16 in.–24 and ⅜ in.–24) Used with adapter 84433 5/16 in.–24, 84434 ⅜ in.–24. (See 80403 and 80404 for moderate use)
84432	Driver—Stud (⅜ in.–24 and 7/16 in.–20). Used with adapter 84435 for ⅜ in.–24 in. studs and adapter 84436, listed under cylinder hold-down stud replacement for 7/16 in.–20. (See 80404 and 80442 for moderate use)
82207	Fixture—Body
83654	Fixture—Cylinder hold-down cap screw hole, tapping
83662	Fixture—Governor drive gear shaft reaming, bench
801505	Fixture—Impeller drive gear shaft outer bushing or impeller drive multi-plate clutch gear bushing installing, arbor press
84854	Fixture—Impeller drive gear shaft outer bushing and impeller drive multi-plate clutch gear bushing removing and hand line reaming
83873	Fixture—Intermediate impeller drive rear bushing line reaming
800065	Fixture—Supercharger rear housing drain valve extension tube spinning and facing
84294	Fixture—Supercharger rear housing sleeve, honing
900061	Fixture and Tools—Impeller drive gear shaft outer bushing removing and hand line reaming
83871	Fixture Tools—Supercharger rear cover bushings replacement (Instruction sheet)
800998	Fixture and Tools—Torque indicator booster pump and governor dis. drive gear shaft bushing replacement
83908	Gage—Accessory drive generator magneto oil pump drive bushing
83878	Gage—Accessory drive and starter bushing limit plug
800130	Gage—Cylinder hold-down capscrew hole, thread maximum wear plug, 7/16 in.–20 (Standard)
800131	Gage—Cylinder hold-down cap screw hole, thread maximum wear plug, 7/16 in.–20 .007 in. O.S.)
800132	Gage—Cylinder hold-down cap screw hole, thread maximum wear plug, 7/16 in.–20 (.012 in. O.S.)
83666	Gage—Governor drive gear shaft bushing bore, limit
800996	Gage—Governor and torque indicator booster pump drive gear shaft bushing shoulder face flange pin
801554	Gage—Impeller drive gear shaft outer bushing pin hole limit plug .1295 dia. .005 in. O.S.
801555	Gage—Impeller drive gear shaft outer bushing pin hole limit plug .1335-.1345 dia. (Used with reamer 801552)
801504	Gage—Impeller drive gear shaft outer bushing or impeller drive multi-plate clutch gear bushing removing boring bar cutter setting
83052	Gage—Impeller drive gear shaft outer bushing or impeller drive multi-plate clutch gear bushing limit plug 1.3155-1.3165 dia. (Used with 83051 reamer)
801614	Gage—Impeller drive gear shaft outer bushing pin hole limit plug .1255-.1265 dia. (Used with reamer 802397)
801556	Gage—Impeller drive gear shaft outer bushing pin hole limit plug .1385-.1395 dia. (Used with reamer 801553)
83231	Gage—Limit plug
83877	Intermediate impeller drive shaft rear bushing
84847	Gage—Straight thread plug (¼ in.-20 standard)
84851	Gage—Straight thread plug (¼ in.-20 .003 in. O.S.)
84538	Gage—Straight thread plug (¼ in.-20 .007 in. O.S.)
84539	Gage—Straight thread plug (¼ in.-20 .012 in. O.S.)

Number	*Name*
84445	Gage—Straight thread plug (5/16 in.-18 standard)
84852	Gage—Straight thread plug (5/16 in.-18 .003 in. O.S.)
84452	Gage—Straight thread plug (5/16 in.-18 .007 in. O.S.)
84453	Gage—Straight thread plug (5/16 in.-18 .012 in. O.S.)
83853	Gage—Straight thread plug (⅜ in.-16 standard)
84853	Gage—Straight thread plug (⅜ in.-16 .003 in. O.S.)
84540	Gage—Straight thread plug (⅜ in.-16 .007 in. O.S.)
84541	Gage—Straight thread plug (⅜ in.-16 .012 in. O.S.)
84880	Gage—Supercharger front housing engine mounting bolt bushing hole limit plug
801202	Gage—Supercharger front and rear housing sleeve and impeller shaft bearing support sleeve finish limit plug (standard)
801473	Gage—Supercharger front and rear housing sleeve and impeller shaft bearing support grind semi-finish limit plug
801489	Gage—Supercharger front and rear housing sleeve and impeller shaft bearing support grind semi-finish limit plug (.010 in. O.S.)
802792	Gage—Supercharger front and rear housing sleeve and impeller shaft bearing support sleeve grinding semi-finish St. plug (Std. .005 in. O.S. and .010 in. O.S.)
801474	Gage—Supercharger front and rear housing sleeve and impeller shaft bearing support sleeve honing finish limit .005 in. O.S.
801488	Gage—Supercharger front and rear housing sleeve and impeller shaft bearing support sleeve honing finish limit plug .010 O.S.
801201	Gage—Supercharger front and rear housing sleeve honing and oil seal ring lapping tools
801092	Gage—Supercharger rear cover starter pad stud hole, straight thread plug (.003 in. O.S.)
801093	Gage—Supercharger rear cover starter pad stud hole, straight thread plug (.007 in. O.S.)
801094	Gage—Supercharger rear cover starter pad hole stud, straight thread plug (.012 in. O.S.)
801205	Gage—Supercharger rear housing sleeve shoulder face, flush pin
81403	Handle—Hollow 7/16 in. dia.
83653	Holder—Cylinder hold-down cap screw hole, tapping
802116	Hone—Supercharger front and rear housing impeller shaft sleeve pin hole drill and ream
802321	Hone and Instruction Sheet—Supercharger front and rear housing impeller shaft sleeve and support grinding and honing and oil seal ring lapping
800781	Installing Tool—Intermediate impeller shaft rear bushing
802801	Instruction Sheet—Removing and installing screw bushings. Used with the following tools for each screw bushing listed

FOR 1/4-28 × 7/16-20 HEADLESS TYPE SCREW BUSHING, 5042-D-2, 5043-D-2, 5044-D-2

801253	Gage—Screw bushing thread plug 7/16-20 (.003 in. O.S.)
801254	Gage—Screw bushing thread plug 7/16-20 (.007 in. O.S.)
801255	Gage—Screw bushing thread plug 7/16-20 (.012 in. O.S.)
802820	Installing Tool—Screw bushing ¼-28
801160	Removing Tool—Stud (⅜-16 std.)
800637	Tap—Screw bushing 7/16-20 (.003 in. O.S.)
800638	Tap—Screw bushing 7/16-20 (.007 in. O.S.)
800639	Tap—Screw bushing 7/16-20 (.012 in. O.S.)
800643	Tap—Screw bushing 4-28 (standard)

BUSHING 5042-D-3, 5043-D-3)
FOR 5/16-24 × 1/2-20 HEADLESS TYPE SCREW

802814	Gage—Screw bushing thread plug ½-20 (.003 in. O.S.)
802815	Gage—Screw bushing thread plug ½-20 (.007 in. O.S.)
802816	Gage—Screw bushing thread plug ½-20 (.012 in. O.S.)
802821	Installing Tool—Screw bushing 5/16-24
201163	Removing Tool—Cylinder hold-down taper stud (½-11-.043 in. taper)
84840	Tap—Screw bushing ½-20 (.003 in. O.S.)
83639	Tap—Screw bushing ½-20 (.007 in. O.S.)
84610	Tap—Screw bushing ½-20 (.012 in. O.S.)
83642	Tap—Screw bushing 5/16 (standard)

Number	*Name*
	FOR 5/16-24 × 1/2-20 9/16 HEX. TYPE SCREW BUSHINGS 4015-D-3, 4016-D-3
800976	Cutter—Screw bushing facing and countersinking counterbore
802814	Gage—Screw bushing thread plug ½-20 (.003 in. O.S.)
802815	Gage—Screw bushing thread plug ½-20 (.007 in. O.S.)
802816	Gage—Screw bushing thread plug ½-20 (.012 in. O.S.)
82297	Holder—Intake and exhaust valve guide removing counterbore, cutter pilot and nut
83641	Pilot—Screw bushing counterbore cutter 5/16 in.-24
801163	Removing Tool—Cylinder hold-down taper stud (½-11-.043 in. taper)
84840	Tap—Screw bushing ½-20 (.003 in. O.S.)
83639	Tap—Screw bushing ½-20 (.007 in. O.S.)
84610	Tap—Screw bushing ½-20 (.012 in. O.S.)
83642	Tap—Screw bushing 5/16-24 (standard)
84840	Tap—Screw bushing ½-20 (.003 in. O.S.)
	FOR 5/16-24 × 1/2, 5/8 HEX. TYPE SCREW BUSHING 19-D-3, 19-D-16
83640	Cutter—Screw bushing facing and countersinking, counterbore
802814	Gage—Screw bushing thread plug ½-20 (.012 in O.S.)
802815	Gage—Screw bushing thread plug ½-20 (.007 in. O.S.)
802816	Gage—Screw bushing thread plug ½-20 (.012 in. O.S.)
82297	Holder—Intake and exhaust valve guide removing counterbore, cutter pilot and nut
801163	Removing Tool—Cylinder hold-down taper stud (½-11-.043 in. taper)
84840	Tap—Screw bushing ½-20 (.003 in. O.S.)
83639	Tap—Screw bushing ½-20 (.007 in. O.S.)
84610	Tap—Screw bushing ½-20 (.012 in. O.S.)
83642	Tap—Screw bushing 5/16-24 (standard)
	FOR 5/16-24 × 9/16-18 HEADLESS TYPE SCREW BUSHING 4-D-16
802817	Gage—Screw bushing thread plug 9/16-18 (.003 in. O.S.)
802818	Gage—Screw bushing thread plug 9/16-18 (.007 in. O.S.)
802819	Gage—Screw bushing thread plug 9/16-18 (.012 in. O.S.)
803358	Installing Tools—Crankcase dowel (crankcase main section)
802821	Installing Tool—Screw bushing 5/16-24
801163	Removing Tool—Cylinder hold-down taper stud (½-11-.043 in. taper)
802805	Tap—Screw bushing 9/16-18 (.003 in. O.S.)
802806	Tap—Screw bushing 9/16-18 (.007 in. O.S.)
802807	Tap—Screw bushing 9/16-18 (.012 in. O.S.)
83642	Tap—Screw bushing 5/16-24 (standard)
802283	Instruction Sheet—Supercharger front and rear housing impeller shaft sleeve grind and hone and oil seal
802697	Jig—Impeller drive gear shaft outer bushing pin hole, drill and ream
800712	Jig—Supercharger rear cover generator pad oil hole headless plug removing drill
803344	Jig—Supercharger rear cover magneto bushing oil hole, drill. Used with Fixtures and Tools 82206 and 83871
801242	Jig—Supercharger rear housing to carburetor adapter stud removing drill, ream and tap 3/8 in.-16 7/16 in.-14
800714	Jig and Tools—Supercharger rear cover generator pad oil hole headless plug, removing
800603	Jig—Supercharger rear housing, impeller shaft sleeve pin hole, drill and ream
801206	Plug—Supercharger rear housing to impeller shaft sleeve screw holes aligning
800602	Plug—Supercharger rear housing impeller shaft sleeve removing and installing, arbor press
83875	Plug and Collars—Supercharger rear cover bushing replacement fixture
84881	Plug and Collar—Supercharging front housing engine mount bolt bushing, installing
802753	Plug and Gage Bar—Supercharger rear housing sleeve and impeller shaft sleeve
83872	Puller—Accessory drive and starter shaft bushing removing
800995	Puller—Governor and torque indicator booster pump drive gear shaft bushing removing and installing
800691	Puller—Intermediate impeller drive shaft rear bushing
802183	Punch—Lock pin removing 5/32 in. dia.
802153	Reamer—Accessory drive generator magneto and oil pump drive gear bushing semi-finish hand

Number	*Name*
802154	Reamer—Accessory drive generator magneto and oil pump drive gear bushing semi-finish hand
802192	Reamer—Accessory drive and starter shaft bushing rough hand
802193	Reamer—Accessory drive and starter shaft bushing finish hand
83663	Reamer—Governor and torque indicator booster pump drive gear shaft bushing, hand 1.0228 dia.
801552	Reamer—Impeller drive gear shaft outer bushing or impeller drive multiplate clutch gear bushing lockpin hole machine .1345 in. dia. .010 O.S.
801553	Reamer—Impeller drive gear shaft outer bushing or impeller drive multiplate clutch gear bushing lockpin hole machine .1395 in. dia. .015 in. O.S.
83051	Reamer—Impeller drive gear shaft outer bushing or impeller drive multiplate clutch gear bushing hand line 1.3163 dia. Used with fixture 84854, 800842 and gage 83052
802397	Reamer—Impeller drive gear shaft outer bushing pin hole machine, .1265 dia. (.002 in. O.S.) Used with jigs 800441, 800923, and in connection with gage 801615
802152	Reamer—Intermediate impeller drive shaft rear bushing, finish hand
802151	Reamer—Intermediate impeller drive shaft rear bushing, semi-finish hand
801250	Reamer—Rear supercharger housing carburetor adapter stud hole, hand (7/16-14 .007 O.S.)
801251	Reamer—Rear supercharger housing carburetor adapter stud hole, hand (7/16-14 .012 O.S.)
82486	Reamer—Supercharger front and rear housing and impeller shaft sleeve lockpin hole machine ext. .188 dia.
84759	Reamer—Engine mounting bolt bushing hole, .6558
800291	Remover—Stud (5/16 in.-24)
800292	Remover—Stud (⅜ in.-24)
800293	Remover—Stud (7/16 in.-20)
801490	Remover—Stud (¼ in.-½)
801162	Removing Tool—Cylinder hold-down stud (7/16 in.-14)
801772	Removing Tool—Supercharger rear cover generator pad oil hole headless plug
83879	Spacers—Supercharger rear cover bushing replacement fixture
800064	Spinning Tools, Drills and Bushings—Supercharger rear housing drain valve extension tube, drill press
800069	Spinning Tool—Supercharger rear housing drain valve extension tube, roughing
800070	Spinning Tool—Supercharger rear housing drain valve extension tube, finish
802118	Stone Assembly—Supercharger front and rear housing impeller shaft sleeve hone, finish Ammco (2.187 dia.)
83717	Tap—⅜ in.-16 U.S.F. (standard)
84231	Tap—¼ in.-20 U.S.F. (.007 in. O.S.)
84232	Tap—¼ in.-20 U.S.F. (.012 in. O.S.)
84233	Tap—5/16 in.-18 U.S.F. (.007 in. O.S.)
84234	Tap—5/16 in.-18 U.S.F. (.012 in. O.S.)
84444	Tap—5/16 in.-18 U.S.F. (standard) supercharger rear cover oil pump mounting pad
84510	Tap—¼ in.-20 U.S.F. (standard)
84848	Tap—¼ in.-20 U.S.F. (.003 in. O.S.)
84849	Tap—5/16 in.-18 U.S.F. (.003 in. O.S.)
800455	Tap—⅜ in.-16 U.S.F. (.003 in. O.S.)
800456	Tap—⅜ in.-16 U.S.F. (.007 in. O.S.)
800457	Tap—⅜ in.-16 U.S.F. (.012 in. O.S.)
800214	Tap—Cylinder hold-down capscrew hole 7/16 in.-20 (standard size)
800127	Tap—Cylinder hold-down capscrew hole 7/16 in.-20 (.007 in. O.S.)
800128	Tap—Cylinder hold-down capscrew hole 7/16 in.-20 (.012 in. O.S.)
801089	Tap—Supercharger rear cover starter pad stud hole, finish (.003 O.S.)
801090	Tap—Supercharger rear cover starter pad stud hole, finish (.007 O.S.)
801091	Tap—Supercharger rear cover starter pad stud hole, finish (.012 O.S.)
800068	Tap—Supercharger rear housing drain valve extension tube
801762	Test Block—15 micro. in.
800963	Tool Box—Supercharger rear housing cover bushing replacement fixture and tools
801501	Tool Bit—Impeller drive gear shaft outer bushing or impeller drive multiplate clutch gear bushing removing bar. Used with 801500

Number	*Name*
84632	Vee Block—Propeller shaft rear bushing pin replacement fixture vee
83759	Wrench—Cylinder hold-down stud removing tool

b. CAM AND CAM DRIVE TOOLS.

803430	Fixture—Cam drive gear bracket
900173	Fixture and Tools—Cam drive gear bracket bushing, removing and install
803429	Gage—Cam drive gear bracket bushing limit plug $\frac{1.016}{1.015}$
803431	Instruction Sheet—Cam drive gear bracket bushing removing and install
803427	Plug and Base—Cam drive gear bracket bushing removing and install arbor press
803425	Reamer—Cam drive gear bracket bushing 1.016 dia.

c. IMPELLER and IMPELLER DRIVE TOOLS.

801017	Adapter—Impeller shaft front and rear bushing removing and finishing fixture. Used with 801001
82361	Bar—Impeller shaft front and rear bushing aligning
802937	Fixture and Holder—Impeller shaft retainer and thrust ring lapping lathe and hand (1.359 O.D.)
801001	Fixture—Impeller shaft front and rear bushing removing and finishing lathe. Used with 801017
84294	Fixture—Supercharger rear housing sleeve
83870	Fixture—Impeller shaft retainer and centering ring lapping, hand. Used with lap 83891
82371	Gage—Impeller shaft front and rear bushing, limit plug (1.312-1.313 in. dia.)
84321	Jig—Intermediate impeller drive gear bushing pin, removing and installing
83891	Lap—Impeller shaft retainer. Used with Fixture 83870
803081	Plug—Impeller low speed drive clutch cam bushing lathe and arbor press
83357	Plug—Impeller shaft rear bushing and impeller shaft retainer centering ring washer installing, arbor press
800091	Plug—Impeller shaft front bushing installing, arbor press single speed supercharger impeller drive
800092	Plug—Impeller shaft front bushing installing, arbor press
800053	Plug—Impeller shaft plain rear bushing pressed .100 in. into the shaft from the anti-propeller end
800819	Puller—Impeller shaft retainer centering ring washer, removing
900055	Removing and Installing Tools—Impeller low speed drive clutch cam bushing lathe and arbor press
803082	Ring—Impeller low speed drive clutch cam bushing removing and facing protector, lathe
83019	Plug and Collar—Intermediate impeller drive gear bushing, removing and installing, arbor press
84322	Reamer—Intermediate impeller drive gear bushing pin hole, machine .1243 dia.
83961	Fixture—Intermediate impeller drive gear bushing finish boring lathe
83023	Plug Gage—Intermediate impeller drive gear bushing limit plug
900115	Removing and Installing Tools—Intermediate impeller drive gear bushing

d. ACCESSORY DRIVE TOOLS.

801227	Adapter—Dual type accessory drive vacuum pump idler gear shaft bushing puller
801228	Adapter—Dual type accessory drive vacuum pump idler gear shaft bushing puller
83929	Adapter—Plate
83827	Adapter—Tachometer and fuel pump drive shaft support bushing removing and finishing, lathe
800031	Base—Fuel pump drive shaft support bushing burnishing, arbor press (used with broach 800032)
83163	Broach—Dual type accessory drive vacuum pump drive gear (large, lower) bushing, hole burnishing
83164	Broach—Dual type accessory drive vacuum pump drive gear (upper) bushing hole burnishing
800032	Broach—Fuel pump drive shaft support bushing, burnishing (used with 800031) 800032 consists of 802319 and 802320
800736	Broach—Gun synchronizer impulse generator drive shaft burnishing, consists of 802323 and 802324

Number	Name
803155	Broach—Tachometer drive shaft bushing burnishing (.4404)
803245	Broach—Tachometer drive shaft gear bushing burnishing (.624-.625)
83534	Collar—Dual accessory drive housing and cover bushing replacement, arbor press
803154	Collar—Tachometer drive shaft gear bushing installing, arbor press
803244	Collar—Tachometer drive shaft gear bushing removing and installing arbor press
83148	Fixture—Dual type accessory drive housing and cover bushing replacing lathe
84684	Fixture—Generator drive gear and plug assembly air test
802100	Fixture and Holder—Accessory drive and starter shaft oil seal packing and retaining ring lapping, machine
803240	Fixture—Tachometer drive shaft gear bushing finish-boring lathe
83826	Fixture—Tachometer and fuel pump drive shaft support bushing removing and finishing lathe
83168	Fixture and Tools—Dual accessory drive housing and cover bushing replacement arbor press and lathe
83161	Gage—Dual type accessory drive gear shaft (large, lower) bushing, limit plug
83162	Gage—Dual type accessory drive intermediate shaft (front) bushing limit plug
83156	Gage—Dual type accessory drive vacuum pump drive gear shaft (small) (lower) bushing, flush pin
83159	Gage—Dual type accessory drive vacuum pump drive gear shaft (small, lower) bushing, limit plug
83157	Gage—Dual type accessory drive vacuum pump idler gear shaft bushing, flush pin
83160	Gage—Dual type accessory drive vacuum pump idler gear shaft bushing, limit plug
83158	Gage—Dual type accessory drive vacuum pump idler gear shaft and drive gear shaft (upper) bushing, flush pin
800033	Gage—Fuel pump drive shaft support bushing and flush pin
84369	Gage—Fuel pump drive shaft support bushing limit plug (.9015-.9025 in. dia.)
800841	Gage—Gun synchronizer impulse generator drive shaft limit plugs 3.751 in.-3.753 in.
82364	Gage—Gun synchronizer impulse generator drive shaft limit plug (.6255 in.-.6265 in. dia.)
83138	Gage—Single and dual type accessory drive intermediate shaft bushing, snap
803156	Gage—Tachometer drive shaft bushing, limit plug (.439-.440)
803241	Gage—Tachometer drive shaft gear bushing flush pin (.474-.478)
800841	Gage—Snap
803242	Gage—Tachometer drive shaft gear bushing limit plug (.624-.625)
800728	Gage—Length
802354	Lap—Magneto and generator drive oil seal collar hand
800754	Plug and Base—Gun synchronizer impulse generator drive shaft installing and burnishing arbor press and drill press
800753	Plug and Base—Gun synchronizer impulse generator drive shaft support bushing removing, arbor press
83835	Plug and Base—Tachometer and fuel pump drive shaft support bushing installing arbor press
84213	Plug—Dual type accessory drive vacuum pump drive gear shaft bushing replacement
84212	Plug—Dual type accessory drive vacuum pump idler gear
83540	Plugs and Collar—Dual type accessory drive housing and cover bushing replacement
803243	Plug—Tachometer drive shaft gear bushing removing and installing arbor press
801226	Puller—Dual type accessory drive vacuum pump drive and idler gear shaft bushing
900107	Removing and Installing Tools—Tachometer drive gear shaft bushings
803157	Removing and Installing Tools—Tachometer drive shaft bushing, arbor press
84215	Tool Box—Dual accessory drive housing and cover bushing replacement fixture and tool

e. CRANKSHAFT TOOLS.

801952	Adapter—Crankshaft rear cheek front face lapping and polishing drill press
84810	Adapter—For stop 83445 front counterweight
802024	Adapter—Propeller shaft bushing lockpin removing tools

Number	Name
84618	Adapter—Propeller shaft bushing replacement
84621	Adapters—Propeller shaft bushing replacement
84616	Adapter—Propeller shaft bushing replacement. Used with 84617
800527	Adapter—Propeller shaft bushing replacement fixture and tools
801101	Adapter—Propeller shaft rear bushing replacement, fixture
84869	Bar—Crankshaft rear counterweight bushing hole alignment checking 1.2858
83523	Base—Crankshaft bushing and crankshaft counterweight bushing removing and installing, arbor press
84309	Base—Propeller shaft front bushing installing
802052	Boring Bar—Propeller shaft front and rear bushing replacement
802059	Boring Bar—Reduction drive pinion gear removing and finishing
801835	Box Assembly—Propeller shaft bushing replacement tools
801849	Bushing—Crankshaft rear cheek front face lapping and polishing drill press
800183	Bushing—Propeller shaft rear bushing pin hole, jig
84619	Bushings—Propeller shaft bushing replacement
84627	Bushing—Propeller shaft bushing replacement
84626	Bushing—Propeller shaft bushing replacement slip. Used with bushing 84617-11
83995	Bushing—Propeller shaft removing steady rest
83921	Chuck—Propeller shaft bushing bar magic. (Used with 800526 and 800525)
84811	Collar—Crankshaft front end bushing installing, arbor press. (Used with plug 84809)
83326	Collar—Crankshaft front and rear end bushing installing arbor press. (Used with plug 83525 and base 83523 for crankshaft rear bushing)
800512	Collar—Crankshaft rear end bushing bearing removing and installing, arbor press. (Used with 83525 for crankshaft rear end bushing bearing and late C9GC)
84904	Drill—Cylinder hold-down stud removing 9/32 in.
801155	Drill—Cylinder hold-down taper stud removing (5/16 in. dia.)
802021	Drill—Propeller shaft pinion gear bushing lockpin removing
802022	Drill—Propeller shaft rear bushing lockpin removing
800186	Drill—Propeller shaft rear bushing pin holes (11/64 in. dia.)
801627	Fixture—Crankshaft crankpin front shoulder polishing drill press
801846	Fixture—Crankshaft rear cheek front face grinding
801628	Fixture—Master rod hub face polishing drill press
84617	Fixture—Propeller shaft bushing replacement
801916	Fixture—Propeller shaft rear bushing installing arbor press
801850	Fixture and Tools—Crankshaft crankpin front and rear shoulder and master rod hub face polishing and lapping drill press or grinder
84631	Fixture—Propeller shaft rear bushing pin replacement holding
800526	Fixture and Tools—Propeller shaft bushing replacement drill press and arbor press
800272	Fixture—Propeller shaft front bushing lathe
83447	Gage—Crankshaft counterweight rear bushing locating, snap (1.995-2.005)
83933	Gage—Propeller shaft rear bushing pin hole, limit plug, .2485-.2495 dia.
800194	Gage—Propeller shaft rear bushing pin hole, limit plug 186-187
83934	Gage—Reduction gear drive bushing pin hole, limit plug .2175 in.-.2185 in. dia.
800993	Installing Tool—Cam bearing ring
84628	Plate—Propeller shaft bushing replacement clamping
801914	Plug and Base—Reduction gear drive pinion bushing installing
84809	Plug—Crankshaft front end bushing and crankshaft front counterweight bushing removing and installing, arbor press
83525	Plug—Crankshaft rear end bushing bearing and counterweight bushing removing and installing arbor press. Used with 83523 and 800512
83524	Plug—Crankshaft rear end bushing and countershaft rear counterweight bushing

Number	Name
	removing and installing arbor press.
84308	Plug—Propeller shaft front bushing installing
801848	Polishing Tool—Crankshaft rear cheek front face drill press
800182	Jig—Propeller shaft rear bushing pin hole, drill and reamer
801322	Holder, Cutter, Pilot—Crankshaft
801333	Polishing Tool—Front crankshaft crankpin shoulder
801547	Polishing Tool—Master rod hub face, drill press
801325	Punch
801317	Punch—Crankshaft front and rear main bearings
802023	Punch—Propeller shaft bushing lockpin removing
801918	Reamer—Propeller shaft rear lock pin hole .249
801917	Reamer—Reduction gear drive pinion bushing pin hole .218
83591	Spinner Tool
802220	Spinning Tool
83445	Stop—Crankshaft front and rear counterweight bushing installing arbor press. Used with adapter 84810
801295	Support
801762	Test Block—15 micro inch finish
800187	Tool Bit—Propeller shaft rear bushing angle relief cutting (0° 20′ 0° 16′)
802047	Tool Box—Propeller shaft bushing replacement tools
802048	Tool Box—Propeller shaft bushing replacement tools
802049	Tool Box—Propeller shaft bushing replacement tools

f. CONNECTING ROD TOOLS.

84401	Adapter—For 84400 for master rods having 1 3/16 in. dia. knuckle pin holes
802250	Adapter—Knuckle pin bushing replacement base and tools. (Used with 802163 and 83373 for 1 3/16 knuckle pin bushing)
802247	Adapter—Piston pin bushing replacement base and tools (thick and thin walls)
802248	Adapter—Piston pin bushing replacement base and tools (thin and thick walls)
801337	Anode—Articulated rod knuckle pin hole lead plating, bench
801336	Anode—Master rod bearing lead plating, bench
84304	Bar—Articulated rod knuckle pin bushing finish bore alignment checking (1.1905 in. dia.) for bushings having 1.1905-1.191 I.D.
803238	Bar—Articulated rod knuckle pin bushing finish bore alignment checking (1.191 dia.) for checking 1.1910-1.1915 I.D.
83568	Bar—Master rod and articulated rod piston pin bushing finished bore alignment checking for bushing having 1.5005-1.5010 I.D.
84302	Bar—Master rod and articulated rod piston pin bushing finished bore alignment checking (1.501 in. dia.) for bushings having 1.5010 in.-1.5015 in. dia. I.D.
83562	Bar—Master rod crankshaft bearing finished bore alignment checking (3.2540 in. dia.) for bearings having 3.2540 in.-3.2545 I.D.
84253	Bar—Master rod crankshaft bearing finished bore alignment checking (3.2535 in. dia.) for bearings having 3.2535-3.2540 dia. I.D.
84254	Bar—Master rod crankshaft bearing finished bore alignment checking (3.2545 in. dia.) for bearings having 3.2545 in.-3.2550 in. I.D.
83560	Bar—Master rod knuckle pin hole alignment checking (1.1465 in.-1.1965) for knuckle pin holes having 1.1465 in.-1.1470 and 1.19656-1.1970 in. I.D.
84306	Bar—Master rod knuckle pin hole alignment checking (1.147 in.-1.197 in.) for knuckle pin holes having 1.147 in.-1.1475 in. and 1.197 in. to 1.975 in. I.D.
83409	Base—Piston pin bushing and knuckle pin replacement arbor drill press
802163	Base and Tools—Piston pin bushing and knuckle pin bushing replacement arbor press and drill press
800079	Body—Master rod crankshaft bearing hole finishing hone
82636	Boring Bar—Master rod crankshaft bearing removing and facing. Used with (2) two tool bits 82637 for removing bearing. Used with one (1) tool bit 82638 for facing bearing on engines equipped with plain type (none-end seal type) master rod

Number	*Name*
83420	Broach—Knuckle pin bushing burnishing (1 3/16 in. dia.)
802402	Broach—Piston pin bushing burnishing
802403	Broach—Piston pin bushing burnishing
802404	Broach—Piston pin bushing burnishing
802405	Broach—Piston pin bushing burnishing
802427	Bushing—Articulated rod knuckle pin hole lead plating, locating. Replacement for detail 8 of 800975
83579	Cap—Piston pin and knuckle pin bushing installing, arbor press
801892	Collars—Piston pin bushing removing, installing, arbor press
801930	Counterbore Cutter—Knuckle pin bushing counterbore, drill press
801926	Counterbore Cutter—Piston pin bushing (thick) counterbore drill press
83208	Counterbore Cutter—Spotfacing counterbore 1 11/16 in. dia.
81362	Counterbore Holder—Spark plug cooler and insert counterbore cutter, drill press
800975	Fixture—Master rod bearing lead plating, bench
800948	Fixture—Master rod bearing lead plating, bench
83819	Fixture—Master rod crankshaft bearing hole honing
84815	Fixture—Master rod crankshaft bearing removing drill press
803321	Fixture—Master rod crankshaft bearing removing reaming
83396	Fixture—Master rod crankshaft bearing spinning and facing drill press. Used with plug and wrench 82713; boring tool 82636; tool bits 82637 and 82638; spinning tools 82815 and 82489; roller 82808 and in connection with gage 82814
83432	Fixture and Tools—Master and articulated rod bearing and bushing bore finishing, hand boring
83433	Fixture and Tools—Master and articulated rod bearing and bushing bore finishing, hand boring
802388	Gasket—Articulated rod knuckle pin hole lead plating fixture
802389	Gaskets—Master rod bearing lead plating fixture
802204	Gage—Articulated rod knuckle pin bushing limit plug 1.1910-1.1915 dia.
802206	Gage—Articulated rod knuckle pin bushing limit plug 1.1915-1.1920 dia.
83419	Gage—Knuckle pin bushing length snap
801179	Gage—Master and articulated rod piston pin bushing limit plug 1.5005 in.-1.5015 in. dia.
82814	Gage—Master rod crankshaft bearing removing boring bar cutter setting. Used with boring bar 82636 and tool bit 82637
800849	Gage—Master rod knuckle pin hole large dia. limit plug, 1.1965-1.197 dia. For rods having 1 3/16 in. dia. knuckle pin holes
800848	Gage—Master rod knuckle pin hole small dia. limit plug 1.1465-1.147 dia. for rods having 1 3/16 in. dia. knuckle pin holes
800041	Head and Brake—Master rod crankshaft bearing hole, finishing hone
800082	Holder—Master rod crankshaft bearing hole finishing hone, stone. (Detail of body 800079)
801928	Pilot and Nut—Piston pin bushing counterbore cutter
83421	Pilot and Nut—Piston pin bushing and knuckle pin bushing facing cutter
802426	Plate—Articulated rod knuckle pin hole lead plating, bottom. Replacement for detail 1 of 800975
84400	Plug and Base—Master rod crankshaft bearing installing arbor press. Used with adapters 84401 for engines equipped with end seal type master rod
802158	Plug and Collars—Knuckle pin bushing removing, installing and burnishing arbor press
83417	Plug—Knuckle pin bushing facing drill press
83415	Plug—Knuckle pin bushing, spinning, drill press
803221	Plug—Master connecting rod prefit bearing removing
84249	Plug—Master rod crankshaft bearing hole honing fixture, locating. Used for engines having a 3.468 in. dia. bearing hole
801890	Plug—Piston pin bushing removing, installing and burnishing, arbor press
83413	Plug—Piston pin bushing spinning and facing, drill press
84819	Reamer—Used with 84815
803322	Reamer—Master rod crankshaft bearing removing

Number	Name
84246	Spacer—For fixture 83819
83373	Spinning Tool—Knuckle pin bushing. (Used with adapters 802494 and 802250)
83345	Spinning Tool—Piston pin bushing
803251	Stand—Master and articulated rod holes alignment checking bench
800081	Stone and Shell—Master rod crankshaft bearing hole finishing stone. (Detail of body 800079)
82637	Tool Bit—Master rod crankshaft bearing removing and boring bar. Used with 82636
802162	Tool Box—Piston pin bushing and knuckle pin bushing replacement base and tools

g. CYLINDER, INTAKE PIPE AND PISTON TOOLS.

Number	Name
803630	Adapter—Cylinder reconditioning drill press
800212	Adapter—Cylinder reconditioning, floor stand
802604	Adapter—Intake and exhaust valve guide cylinder hole and stem hole reamer pilot, bushing and plug
803796	Aligning Tool—Exhaust valve guide cylinder hole and stem hole, reamers
802625	Boring Bar—Intake and exhaust valve guide cylinder hole, drill press
800209	Boring Tool—Bronze valve seat removing and intake and exhaust port shoulder, drill press
800206	Bushing—Exhaust valve guide
804361	Bushing—Exhaust valve guide and boss back spot facing bar
802606	Bushing—Exhaust valve guide stem and cylinder hole and intake valve guide cylinder hole reamer, pilot, .662 I.D.
82536	Bushing—Exhaust valve guide
83768	Bushings—Exhaust valve seat angle grinding wheel, pilot, .686 in. O.D. (Select fit ※1)
83769	Bushings—Same as 83768 only, .688 in. O.D. (Selective fit ※2)
83770	Bushing—Same as 83768 only, .690 in. O.D. (Selective fit ※3)
802607	Bushing—Intake valve guide valve stem hole reamer pilot, .475 in. I.D.
800245	Bushings—Intake-valve seat grinding wheel, pilot .562 in. O.D. (Selective fit ※1)
800246	Bushing—Same as 800245 only, .564 in. O.D. (Selective fit ※2)
800247	Bushing—Same as 800246 only, .566 in. O.D. (Selective fit ※3)
800204	Bushing—Intake valve seat removing tools, pilot, drill press and bench
802956	Collet—Intake and exhaust valve seats and guides removing and installing magic chuck
802184	Cutter—Intake and exhaust valve guide cylinder hole countersink
800331	Cutter—Intake and exhaust valve seat recess counterbore, .010 in. O.S.
800332	Cutter—Intake and exhaust valve seat recess counterbore, .020 in. O.S.
800333	Cutter—Intake and exhaust valve seat recess counterbore, .030 in. O.S.
800334	Cutter—Intake and exhaust valve seat recess counterbore, .040 in. O.S.
82793	Cutter—Spark plug insert back spotfacing countersink, 3/8 in. radius
82776	Cutter—Spark plug insert counterbore
81360	Cutter—Spark plug insert spark plug seat spotfacing, counterbore
81359	Cutter—Spark plug insert thread removing counterbore
800106	Cutter and Bar—Rocker box bolt bushing shoulder facing, hand
801286	Drift—Exhaust valve seat removing
801947	Drift—Intake valve seat removing
802674	Drill—Exhaust valve guide removing
802675	Drill—Intake valve guide removing
801950	Drill—Spark plug insert dowel holes, .120 in. dia.
802097	Driver—Choked and straight cylinder bore, hone
805074	Dummy Guide—Exhaust valve, .9043 in. dia.
805075	Dummy Guide—Exhaust valve, .9143 in. dia.
805076	Dummy Guide—Exhaust valve, .9243 in. O.D.
805077	Dummy Guide—Exhaust valve, .9343 in. O.D.
805078	Dummy Guide—Exhaust valve, .9348 in. O.D.
805079	Dummy Guide—Exhaust valve, .9353 in. O.D.
805080	Dummy Guide—Exhaust valve, .9453 in. O.D.
805081	Dummy Guide—Exhaust valve, .9553 in. O.D.
805087	Dummy Guide—Intake valve, .7176 in. O.D.
805088	Dummy Guide—Intake valve, .7226 in. O.D.
805089	Dummy Guide—Intake valve, .7276 in. O.D.
805090	Dummy Guide—Intake valve, .7376 in. O.D.
805091	Dummy Guide—Intake valve, .7476 in. O.D.
802599	Expansion Plugs—Exhaust valve seat expansion, 2.613 in. O.D.

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Number	Name
802603	Expansion Plugs—Intake valve seat expansion, 2.738 in. O.D.
804360	Facing Bar—Exhaust valve guide and boss back spot facing cutter holder
803100	Fixture—Choked and straight cylinder bore shoulder grinding bench
83450	Fixture—Cylinder honing
803628	Fixture—Cylinder reconditioning, drill press
82955	Fixture—Cylinder reconditioning, drill press
801830	Fixture—Wedge type piston ring groove, reconditioning lathe
801830	Fixture—Wedge type piston ring groove, reconditioning
800843	Gage—Cylinder flange face, bluing
803303	Gage—Exhaust valve guide and boss lower face, flush pin 1.922 in. long
803920	Gage—Exhaust valve seat bluing and limit
803919	Gage—Intake valve seat bluing and limit
800111	Gage—Rocker box bolt bushing, limit plug, .5635 in.-.5655 in. dia.
800109	Gage—Rocker box bolt bushing shoulder face width
802688	Gage—Spark plug cooler and insert cylinder hole thread plug, 1-14 pitch
802689	Gage—Spark plug cooler and insert cylinder hole thread plug, 1-14 pitch, .030 in. O.S.
802690	Gage—Spark plug cooler and insert I.D. hole thread plug, 18m/m × 1.5 m/m standard
801059	Gage—Spark plug cooler and insert spark plug seat bluing
802621	Temperature Gage—Cylinder head heating
803720	Gage—Wedge type piston ring groove grooving tool checking
801783	Gage—Wedge type piston ring groove maximum wear limit, snap
801097	Grooving Tool—Wedge type piston ring groove, lathe
84710	Guide—Cylinder hone
81174	Handle—Intake and exhaust valve seat installing tool
82519	Handle—Intake and exhaust valve seat O.S. recess and intake valve seat angle, cutters, turning handle
81403	Handle—7/16 in. dia., hollow
900064	Heating Tools—Intake and exhaust valve seats and guides, removing and installing
802098	Holder—Choked and straight cylinder bore hone, stone and shell
803094	Holder—Cylinder head heating
801463	Holder—Intake and exhaust valve guide cylinder hole countersink cutter, hand turning
83047	Holder—Spark plug cooler and insert spot facing cutter, hand turning
803676	Holder—Spark plug insert counterbore cutter, drill press
802096	Hone Assembly—Choked and straight cylinder bore, honing holder
82125	Installing Arbor—Exhaust valve guide
800356	Installing Arbor—Exhaust valve seat
800573	Installing Arbor—Intake valve guide
800354	Installing Arbor—Intake valve seat
802605	Installing Tool—Intake and exhaust valve guide cylinder hole and stem hole reamer, pilot, bushing and plug adapter
803675	Installing Tool—Spark plug insert
803264	Instruction Sheet—Crooked and straight cylinder bore shoulder grinding, bench
82522	Jack—Intake and exhaust valve seat recess cutters turning
81323	Jig—Spark plug insert dowel hole, drill
800985	Lap—Cylinder flange face, hand
802622	Nozzle—Cylinder head heating
800101	Nut—Rocker box bolt bushing shoulder facing locating
82794	Pilot and Bushing—For 82793 cutter, drill press
82532	Pilot—Intake and exhaust valve seat O.S. recess cutters
83049	Pilot and Nut—For 81360, threaded 18 m/m-1.5 m/m pitch
81363	Pilot and Nut—Spark plug insert counterbore cutter
83031	Pilot and Nut—Same as 83029 only, .015 in. O.S.
83032	Pilot and Nut—Same as 83029 only, .030 in. O.S.
83767	Pilot, Washer and Nut—Exhaust valve seat angle grinding wheel (used in connection with standard portable motor driven flexible shaft equipment having shaft with a 1/4 in. collet, see 800642)

Number	*Name*
800642	Pilot, Washer and Nut—Exhaust valve seat grinding wheel (same information as 83767 only 5/16 in. collet, see 83767)
800188	Pilot, Washer and Nut—Intake (steel) valve seat grinding wheel (used in connection with standard portable motor driven flexible shaft equipment having shaft with 1/4 in. collet)
800653	Pilot, Washer and Nut—Same as 800188 only 5/16 in. collet (see 800188)
804631	Plug—Cylinder reconditioning drill press fixture cylinder locating
800100	Plug—Rocker box bolt bushing shoulder facing, locating
800103	Plug—Rocker box bolt bushing facing locating, intake
800104	Plug—Rocker box bolt bushing facing locating, exhaust
801643	Plug—Intake (steel) and exhaust valve seat removing
81475	Plug Gage—Exhaust valve guide cylinder hole, limit plug, .040 in. O.S.
801387	Plug Gage—Exhaust valve guide cylinder hole, limit plug, .050 in. O.S.
801388	Plug Gage—Exhaust valve guide cylinder hole, limit plug, .060 in. O.S.
801389	Plug Gage—Exhaust valve guide cylinder hole, limit plug, .070 in. O.S.
80431	Plug Gage—Exhaust valve guide cylinder hole, limit plug, .010 in. O.S.
80852	Plug Gage—Exhaust valve guide cylinder hole, limit plug, .020 in. O.S.
81473	Plug Gage—Exhaust valve guide cylinder hole, limit plug, .030 in. O.S.
81477	Plug Gage—Exhaust valve guide cylinder hole, limit plug, .065 in. O.S.
82755	Plug Gage—Exhaust valve guide cylinder hole, limit plug, .005 in. O.S.
82641	Plug Gage—Exhaust valve guide stem hole, limit plug, .686-.687 in. dia.
800346	Plug Gage—Intake valve guide cylinder hole, limit plug, .010 in. O.S.
800345	Plug Gage—Intake valve guide valve stem hole, limit plug, .562-.563 in. dia.
804926	Plug Gage—Intake valve guide cylinder hole, limit plug, .080 in. O.S.
804927	Plug Gage—Intake valve guide hole, limit plug, .090 in. O.S.
803093	Protector—Cylinder head heating
800462	Protector—Steel valve seat removing cylinder wall
81171	Puller—Intake and exhaust valve seat installing tool
800099	Puller—Rocker box bolt bushing, removing and installing
802575	Punch—Exhaust valve guide removing, .845 in. dia.
801642	Punch—Intake (steel) and exhaust valve seat removing
802841	Punch—Intake valve guide removing
805168	Reamer—Exhaust valve guide cylinder hole machine, .8803 dia., .005 in. O.S.
805166	Reamer—Exhaust valve guide cylinder hole machine, .8853 in. dia., .010 in. O.S.
805167	Reamer—Exhaust valve guide cylinder hole machine, .8953 in. dia., .020 in. O.S.
805164	Reamer—Exhaust valve guide cylinder hole machine, .9053 in. dia., .030 in. O.S.
805165	Reamer—Exhaust valve guide cylinder hole machine, .9153 in. dia., .040 in. O.S.
805160	Reamer—Exhaust valve guide cylinder hole machine, .9253 in. dia., .050 in. O.S.
805161	Reamer—Exhaust valve guide cylinder hole machine, .9353 in. dia., .060 in. O.S.
805163	Reamer—Exhaust valve guide cylinder hole machine, .9403 in. dia., .070 in. O.S.
805191	Reamer—Exhaust valve guide cylinder hole machine, .9503 in. dia., .080 in. O.S.
805022	Reamer—Exhaust valve guide cylinder hole machine, .9603 in. dia., .090 in. O.S.
804582	Reamer—Exhaust valve guide valve stem hole machine, standard size
805173	Reamer—Intake valve guide cylinder hole machine, .005 in. O.S.
805170	Reamer—Intake valve guide cylinder hole machine, .010 in. O.S.
805171	Reamer—Intake valve guide cylinder hole machine, .020 in. O.S.
804581	Reamer—Intake valve guide valve stem hole machine, standard size
800108	Reamer—Rocker box bolt bushing, hand line, .5653 in. dia.
860062	Removing and Installing Tools—Spark plug insert (instruction sheet)

Number	*Name*
801287	Setting Gage—Exhaust valve seat, port shoulder boring tool, cutter
801948	Setting Gage—Intake valve seat port shoulder boring tool, cutter setting
84938	Stand—Cylinder reconditioning, floor
800207	Stand—Intake (steel) and exhaust valve seat removing bench
802099	Stone and Shell—Choked and straight cylinder bore hone
81357	Tap—Same as 81356 only, .015 in. O.S.
82567	Tap—Same as 81356 only, .030 in. O.S.
81355	Tap—Spark plug insert spark plug hole, 18 m/m-1.5 m/m pitch
805156	Tool Bit—Exhaust valve guide cylinder hole boring bar
802888	Tool Bit—Exhaust valve and boss back spot facing cutter
805157	Tool Bit—Intake valve guide cylinder hole boring bar
800606	Wheel—Intake and exhaust valve seat angle finishing
83169	Wrench—For intake valve guide valve stem hole hand expansion reamer, socket, 5/16 in. square

b. VALVE MECHANISM TOOLS.

800540	Arbor—Valve tappet roller polishing
800357	Cleaning Tool—Exhaust valve stem 11/16 in.
801599	Holder—Intake and exhaust valve stem polishing, lathe

i. MISCELLANEOUS TOOLS.

802924	Sealer—Plasticfilm bag, heating iron (115 V. Alternating Current)
84535	Puller—Cam bearing ring, remover

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SECTION IV
DISMANTLING AND DISASSEMBLY

1. GENERAL.

a. The procedure outlined in this section covers dismantling of the engine into its major component parts or sub-assemblies.

b. As parts or sub-assemblies are removed from the engine, they should be placed on a portable rack preparatory to being cleaned. Small boxes, tins or other receptacles should be provided in which bolts, nuts, washers, and other small parts can be placed as they are removed.

c. During the various stages of dismantling close observation must be made of all parts for signs of scoring or burning because of undue friction. Many valuable indications of defects can be obtained when the oil or the loosened surface of the metal is present. Washing will remove some of these indications.

d. The propeller shaft hub nut threads on the front end of the shaft will, whenever possible, be covered with a suitable thread protecting cap (Tool No. 83922).

2. MOUNTING ENGINE ON DISASSEMBLY STAND.

a. Insert the hook on the chain hoist through the engine hoisting eye (Tool No. 83761), which is installed on the propeller shaft. Lift the engine by means of a suitable chain hoist of not less than one ton capacity until it is suspended in a front-end-up position. If an engine hoisting sling is attached to the intake rocker box studs on cylinders No. 1 and 9, remove the sling.

b. Move a revolving cradle type engine assembly and disassembly stand (consisting of base, Tool No. 83678, and mounting plate, Tool No. 83679) directly under the engine. Turn the mounting plate to receive the engine in a front-end-up position, and lock the mounting plate in that position. Lower the engine onto the stand so that the carburetor is located in the center of the cutaway portion of the mounting plate. Refer to Figure 39. Attach the engine securely to the mounting plate using five nuts and bolts through the mounting lug holes in the supercharger front housing.

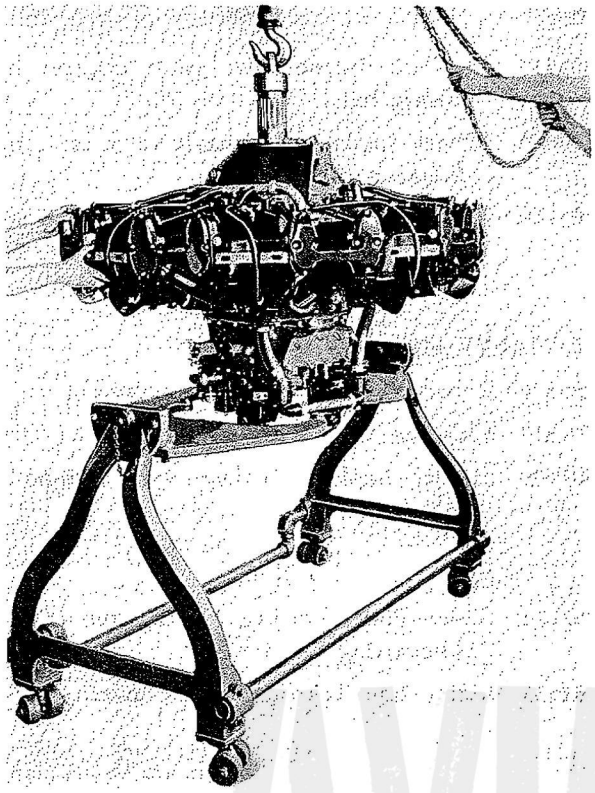

Figure 39—Mounting Engine on Disassembly Stand

Install a plain washer between each mounting bolt nut and the front face of the mating engine mounting lug to prevent the nut from damaging the supercharger front housing. Remove the hoist and hoisting eye.

c. Turn the mounting plate until the engine is in the normal flight position, and lock the mounting plate in this position.

d. Place the propeller shaft thrust bearing nut lug wrench (Tool No. 82889) and the propeller shaft turning tool over the propeller shaft. Hold the propeller shaft turning tool and loosen the thrust bearing nut one or two turns. Refer to Figure 40. It is desirable to loosen the thrust nut while the shipping plugs or spark plugs are still in the cylinders so that the cylinder compression will prevent the propeller shaft from turning when the propeller thrust nut wrench is applied.

3. SPARK PLUGS.

a. Loosen the spark plug terminal elbow coupling nut from all spark plugs. Withdraw the elbows from all spark plugs, and remove the plugs. Refer to Figure 41. Use spark plug wrench (Tool No. 84450). Place the spark plugs in a board having drilled holes to accommodate the electrode end of the plug. Install vented dummy plugs in the spark plug holes in all cylinders. Install a cover (Tool No. 800910) over the exhaust port in all cylinders.

Figure 40—Deleted in revision dated April 15, 1944

4. PRIMING SYSTEM.

a. Three systems of engine priming are commonly employed. In one system, the priming charge is directed into the carburetor adapter and the supercharger front housing. In the second system, the priming charge is directed into the intake ports of the upper five cylinders. The third system directs the priming charge into the supercharger front housing.

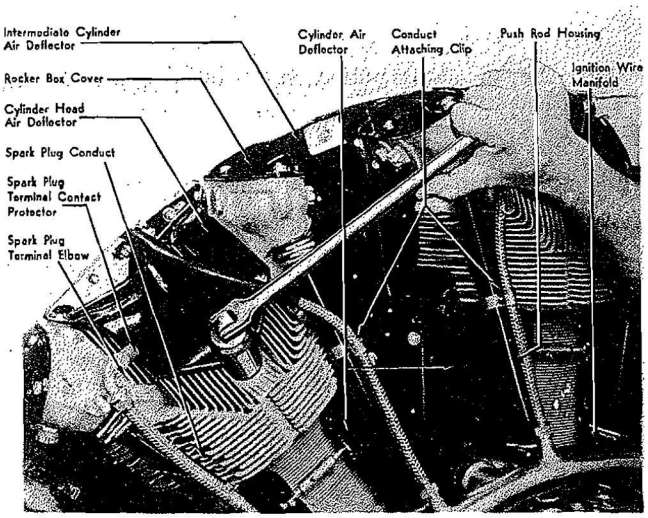

Figure 41—Removing Spark Plug

These are called two-point, five-point and one-point systems, respectively.

b. On engines which are primed through the carburetor adapter and the supercharger front housing, remove the priming lines and their attaching brackets, the priming nozzles, priming distributor, all hoses and tubing to the distributor from the carburetor and solenoid, and solenoid and the electrical junction box and conduits. Tag all priming lines, hoses, and tubing to insure that they will be installed in their original positions on the engine after the engine is reassembled.

c. On engines which are primed through the intake ports of the upper five cylinders, unscrew the union nuts from the priming tube fittings in the intake ports of the upper five cylinders and from the nipples on the priming distributor. Remove the nuts, washers, and bolts which attach the priming tube clamps to the intake pipes, and remove the priming tubes. Tag all priming tubes so that they will be installed in their original position on the engine after the engine is reassembled. Detach the priming system supply line from the distributor.

d. On engines incorporating one-point priming, remove the priming line and all connections from the supercharger front housing.

5. OIL DILUTION SYSTEM.

a. If an oil dilution system is used, disconnect the oil dilution valve from the oil inlet line to the engine oil pump and disconnect the oil dilution supply line from the carburetor. Remove the oil dilution supply line and valve.

6. BENDIX STROMBERG CARBURETOR.

a. Remove the ten palnuts, nuts, and washers from the carburetor air scoop attaching studs. Remove the carburetor air inlet screen and two gaskets. Remove the eight Elastic stop nuts and spherical seat washers which attach the carburetor to the supercharger rear housing. Remove the carburetor and gasket. Cover the opening to the induction passage in the rear housing with a suitable plate drilled to pass over the carburetor adapter studs.

7. ACCESSORIES.

a. Remove the vacuum pump, electric tachometer, and other spare drive accessories, if used, from their respective mounting pads. Remove the generator. Open end wrench (Tool No. 801080) is designed to provide accessibility to the generator attaching nuts. Remove the starter. Box wrench (Tool No. 801081) and open end wrench (Tool No. 84654) are designed to provide accessibility to the starter attaching nuts. Remove the two magnetos in accordance with the following instructions: Remove the six cap screws and lock washers which secure the coil cover to the front end of each magneto, passing through the radio shield assembly. Remove the two cap screws which secure the coil cover to the housing of each magneto at the breaker end of the housing. Lift off the coil covers. Pull the radio shield assembly of each magneto, in which the distributor block is housed, back toward the coil to disengage it from the front end plate of each magneto, and then lift the radio shield assemblies away from the magnetos. Refer to Figure 42. Remove both magnetos. Refer to Figure 43. The radio shield assembly and distributor block of each magneto, and the crossover conduit attached to the two radio shield assemblies, will remain attached to the ignition wiring manifold.

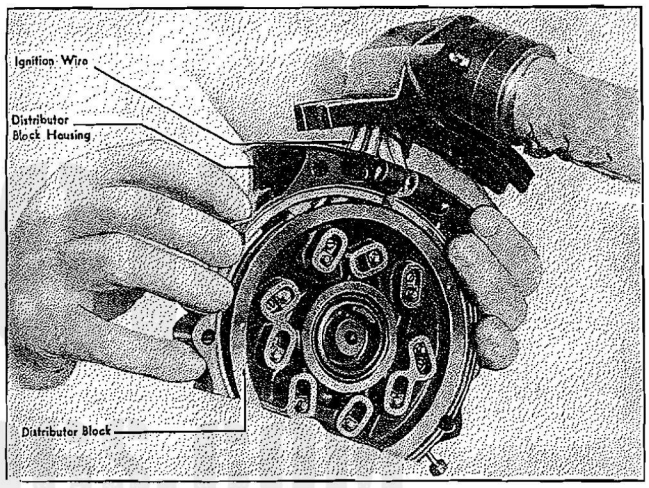

Figure 42—Removing Magneto Block Housing

b. Remove the fuel pump from its mounting pad on the supercharger rear housing.

c. Remove the propeller governor, if used, from the crankcase front section.

8. INTAKE PIPES.

a. Loosen the packing nut at the crankcase end of all intake pipes, using the lug wrench (Tool No. 84258). Refer to Figure 44. Remove the three cap screws and shakeproof lock washers at the cylinder end of all intake pipes. Pull the flange back from the intake port on each intake pipe. Discard the gaskets and packing. Withdraw the intake pipes from the supercharger front housing.

b. Install a cover (Tool No. 800909) over the intake port of all cylinders, and install a cover (Tool No. 800907) in all pipe packing nuts in the supercharger front housing. Refer to Figures 45 and 46.

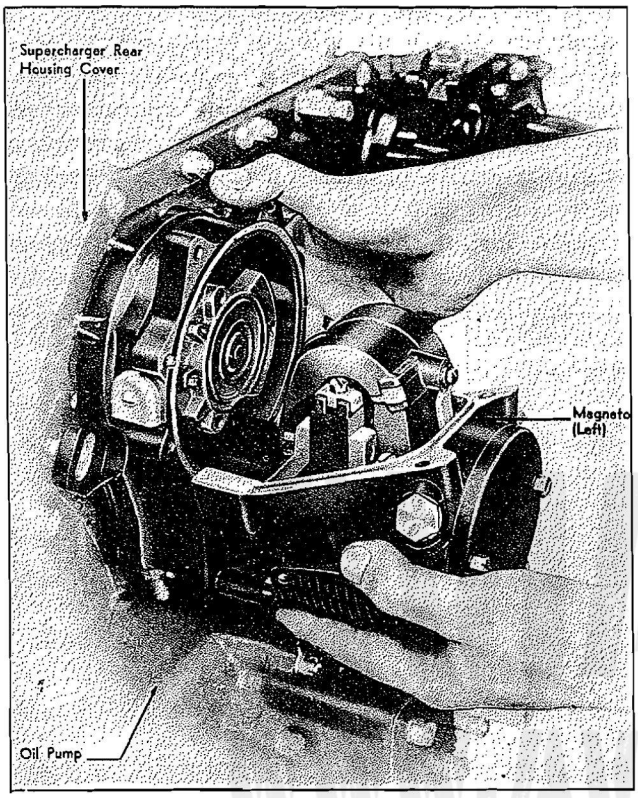

Figure 43—Removing Magneto

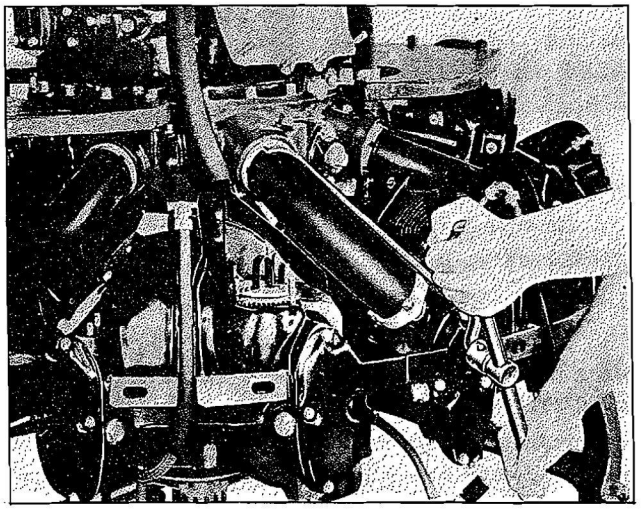

Figure 44—Loosening Intake Pipe Packing Nut

9. AIR DEFLECTORS.

a. Withdraw the rear spark plug conduits from the channel section in each cylinder head air deflector. Break the lock wire from the fillister head screw attaching each cylinder head air deflector at the cylinder intake port, and remove these screws. Break the lock wire from the two fillister head screws at the top of each deflector and remove these screws. The cross member of the deflector is slotted to permit easy access to these screws with a screw driver. Remove the cylin-

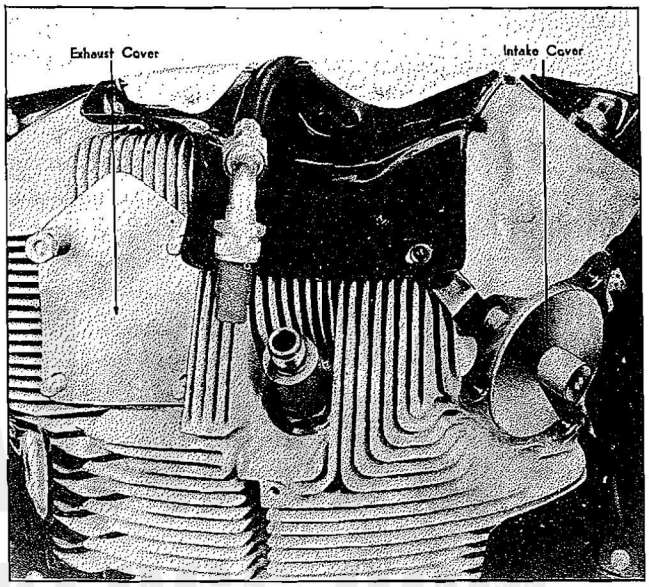

Figure 45—Location of Intake and Exhaust Covers

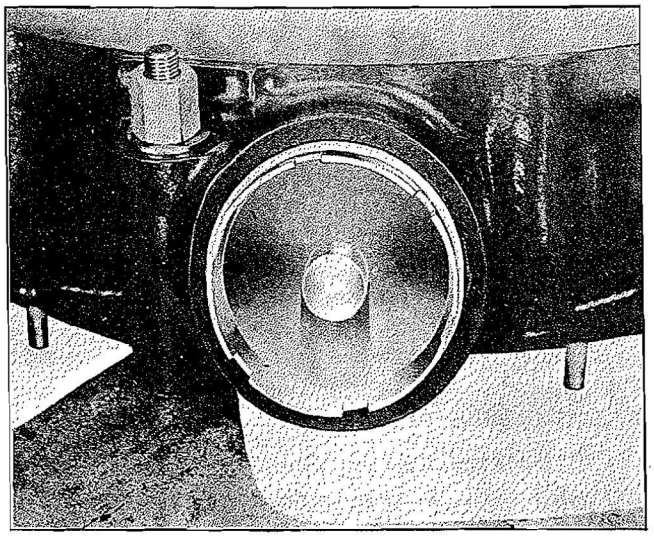

Figure 46—Intake Pipe Packing Nut Cover Location

der head air deflectors. Place deflectors in a large container. Refer to Figure 47.

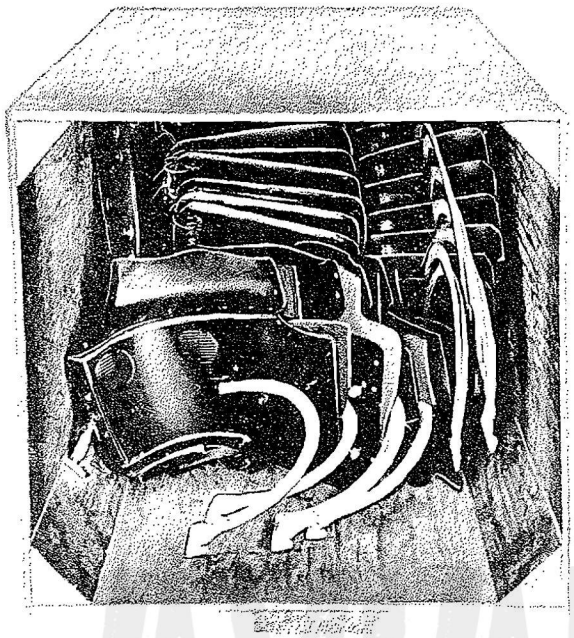

Figure 47—Air Deflectors in Container

b. Remove the elastic stop nut and washer from the through bolts which secure the inter-cylinder air deflector clamps. Remove the clamps, bolts and spacers, and reassemble these parts after removal to prevent loss. Remove the nuts, plates, and grommets from the studs which attach the deflectors to the rocker box cover extensions. Remove the intercylinder air deflectors from the rear. Reinstall the plates and rubber grommets to the stud on the deflectors to prevent loss of these parts.

c. The instructions in the previous paragraph apply to all intercylinder air deflectors except the one located at the sump section. To remove this intercylinder air deflector, remove the nut, plate, and grommet which secure the deflector to the rocker box cover extensions. Break the lock wire and remove the two cap screws which attach the deflector to the arms of the sump. Withdraw the deflector to the rear.

10. EXTERNAL OIL LINES.

a. Disconnect the external hydro oil line at the front and rear sections. Disconnect the external oil scavenge line from the sump adapter and oil pump. Remove the brackets and supports from each line. Remove the tubes.

11. OIL SUMP.

a. Remove the magnetic drain plug from the bottom of the sump. Drain the oil from the sump if this has not already been done. If the engine does not incorporate an external oil scavenge line, remove the screened sump plug by using wrench (Tool No. 82058). If the engine incorporates an external oil scavenge line, remove the scavenge tube adapter plug using wrench (Tool No. 803152). Remove the adapter and gaskets. Using wrench (Tool No. 803146) remove the screened sump plug. Remove the three palnuts, nuts, and washers which secure the front sump attaching flange to the crankcase front section. Hold the sump and remove the two palnuts, nuts, and washers which attach each arm of the sump to the supercharger front housing. Remove the sump.

12. IGNITION WIRING MANIFOLD ASSEMBLY.

a. With the engine supported on the mounting stand in the horizontal flight position, remove the clips which attach the spark plug conduits to the push rod housings. Remove the clamp which attaches the left main magneto conduit to the bracket installed under two supercharger rear housing attaching nuts. Do not remove the bracket at this time. If extended type rocker box covers are used, it will be necessary to remove the four upper rocker box covers before removing the ignition wiring manifold assembly, since the extended portion of the covers will not permit the main magneto conduits to pass through. In such cases, remove the intake rocker box cover of cylinder No. 9, both intake and exhaust rocker box covers of cylinder No. 1, and the exhaust rocker box cover of cylinder No. 2.

b. Turn the mounting plate on the engine disassembly stand until the engine is supported in the front-end-up position, and lock the mounting plate in this position. Remove the four clips which attach the manifold to four supports installed under the crankcase front section attaching cap screws. These clips are of special design so that they may be withdrawn from the manifold and support after loosening the clamping screw and removing the hook on the clip from the slot in the band.

c. It will be necessary to raise the engine slightly from the mounting plate at this time in order that the left main magneto conduit may be withdrawn

from its present position between the mounting plate and the supercharger front housing. Install the hoisting eye (Tool No. 83761) on the propeller shaft threads. Remove the five mounting bolts which attach the engine to the mounting plate, and using a chain hoist, raise the engine approximately two inches above the mounting plate. Remove the ignition wiring manifold assembly, including the magneto radio shield assemblies, distributor blocks, and cross-over conduit, by lifting over cylinder No. 1. Reinstall the engine on the mounting plate.

d. Remove the spark plug terminal contact sleeves from the ends of the ignition cable. Loosen the coupling securing each spark plug terminal elbow to the shielded spark plug conduits and withdraw the elbows and rubber washers. Unscrew the coupling attaching each spark plug conduit to the manifold and withdraw the spark plug conduits and rubber washers from the ignition cables.

e. Loosen the knurled nut attaching each half of the horseshoe-shaped manifold to the manifold elbows, and withdraw the two halves of the manifold from the ignition cables. Loosen the coupling attaching each manifold elbow to the main magneto conduits and withdraw the two elbows in the same manner.

f. Remove the two cap screws at the base of each magneto radio shield assembly, which secure the distributor blocks. Remove the two cap screws and washers in slots in each magneto outlet adapter, which attach the adapter to the radio shield. Remove the clamping screws which hold the two halves of the shields together, and remove the shields.

g. Remove all ignition cable piercing screws in both distributor blocks, and withdraw both distributor blocks from the ignition cables. Refer to Figure 48.

h. Remove the two cap screws which attach each magneto outlet elbow and front flange to the magneto outlet adapters. Withdraw each main magneto conduit casing and magneto outlet front flange from the ignition cables. Withdraw the two magneto outlet adapters in the same manner, allowing the short ends of the cables which were attached to the distributor blocks to pass up through the hole in the bottom of each adapter.

i. Unscrew the knurled nuts at each end of the cross-over conduit. Withdraw the two magneto outlet flanges from the ignition cables, and withdraw the cross-over conduit casing in the same manner.

j. Discard the ignition cables. Reinstall the distributor blocks, radio shields, magneto outlet adpters, and coil covers in the proper magnetos.

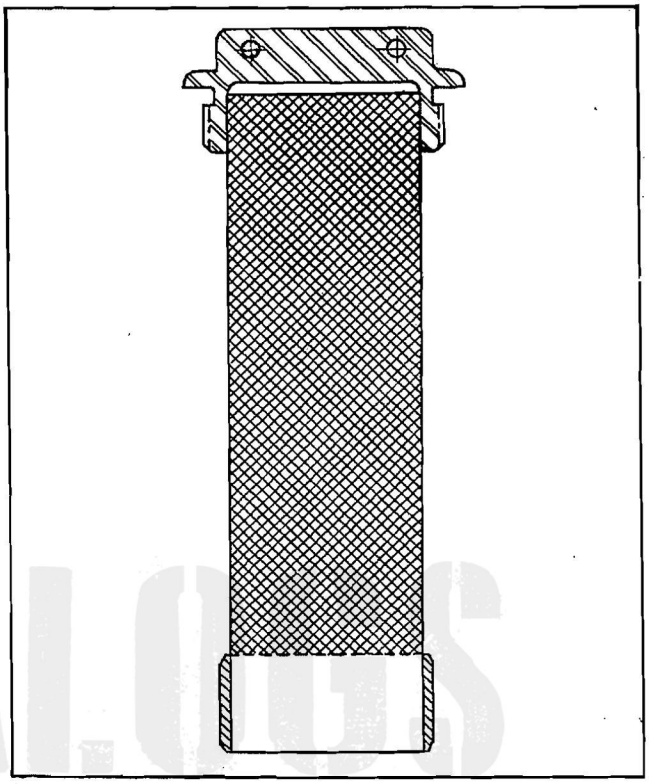

Figure 48—Sump Plug

13. ROCKER BOX COVERS.

a. With the engine supported in a front-end-up position, and the mounting plate locked in that position, remove the nuts, lock washers, and plain washers from the four rocker box cover attaching studs on all rocker boxes. Speed wrench (Tool No. 84566) is recommended for use in removing rocker box cover attaching nuts. This wrench is provided with a hollow body in which the nuts are contained after removal. Magnet (Tool No. 84770) is recommended for rapid removal of the lock washers and plain washers from the rocker box cover attaching studs. Remove all rocker box covers and gaskets. Discard the gaskets.

14. ROCKER ARMS AND PUSH RODS.

a. Remove the cotter pin from the rocker arm hub bolt nut in all rocker boxes. Remove the rocker arm hub bolt nuts. Turn the crankshaft until one valve is contacting its seat and a clearance exists between the rocker roller and the valve system. To turn the crankshaft, use the turning tool (Tool No. 82284),

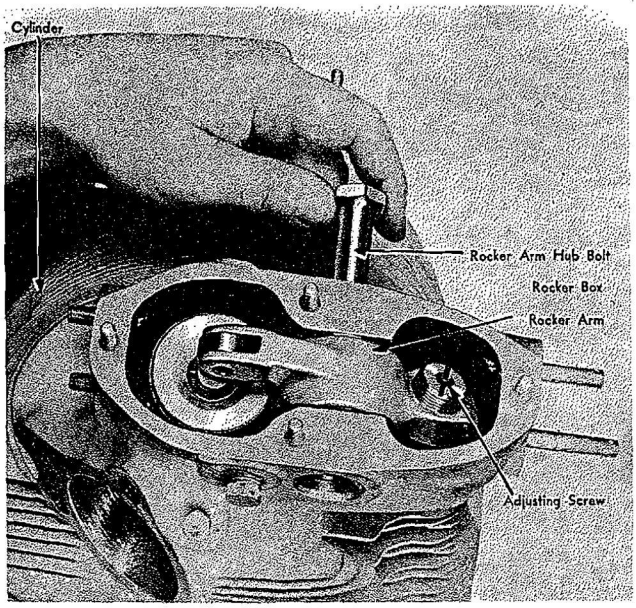

Figure 49—Removing or Installing Rocker Arm Hub Bolt

which is installed on the propeller shaft splines, and two handles (Tool No. 80292). Push out the rocker arm hub bolt, being careful not to damage the threads on the end of the bolt. Refer to Figure 49. Remove the two spherical seat washers. Lift the rocker arm and push rod out of the rocker box. Place the push rods in a storage box. Refer to Figure 50.

b. Repeat this operation for removing all rocker arms and push rods. Remove the clamping screw and valve clearance adjusting screw from all rocker arms using wrench (Tool No. 802581). Refer to Figure 51.

WARNING

The valve clearance adjusting screw must be removed socket-end first. There is a flange on the outside diameter of the screw at the socket end which will not permit removal of the screw slotted end first.

c. Press the rocker arm bearing out of each rocker arm using an arbor press and the fixture and plug (Tool No. 801895) designed for this purpose. Refer to Figure 52. Place the rocker arms, bearings, clamping screws and adjusting screws in a box having eighteen individual compartments, one for each rocker arm assembly, in order that the parts of each assembly may be kept together. Refer to Figure 53.

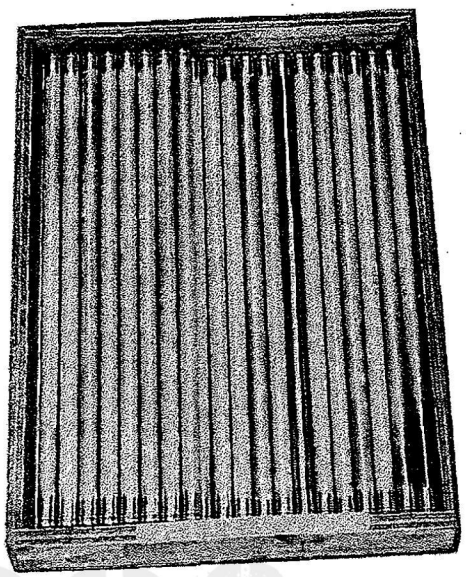

Figure 50—Push Rod Storage Box

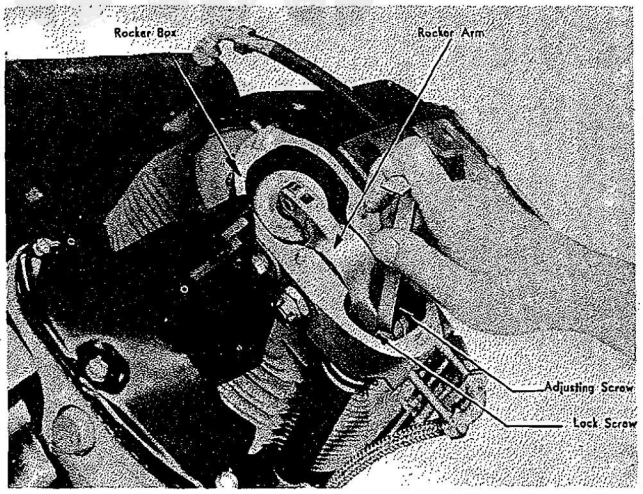

Figure 51—Loosening or Tightening Adjusting Screw Lock Screw

15. PUSH ROD HOUSINGS.

a. Loosen the clamps at each end of each push rod housing. Slide the housing inward, toward the crankcase front section. Lift the rocker box end of the push rod housings up, and remove the housings by pulling outward, away from the engine. Remove the hoses

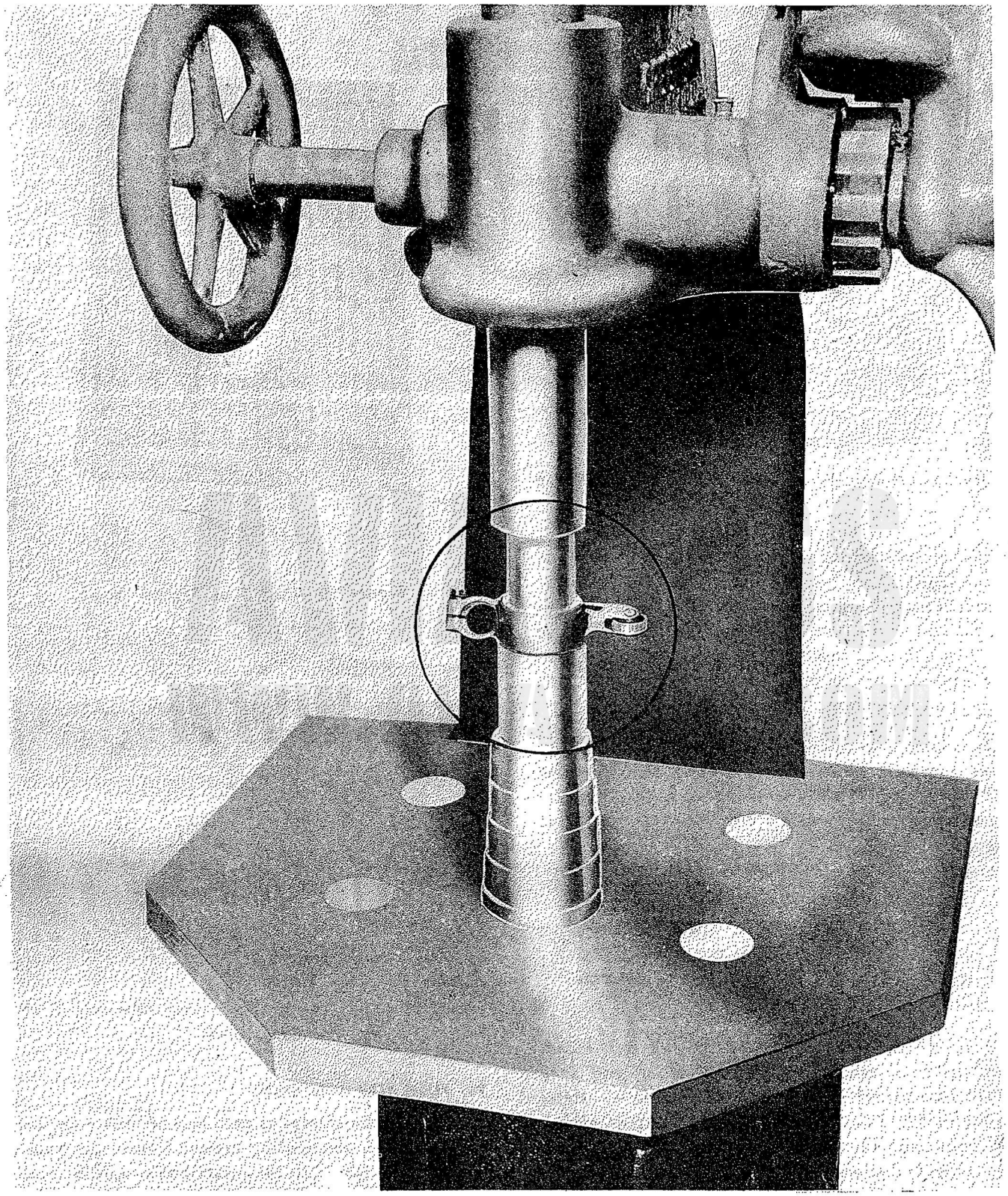

Figure 52—Removing Rocker Arm Bearing

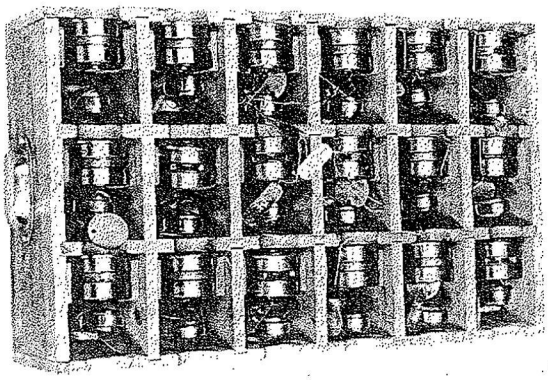

Figure 53—Rocker Arm Storage Box

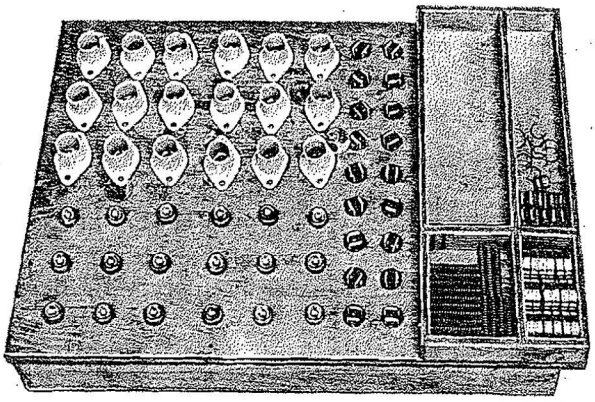

Figure 55—Valve Tappet Storage Box

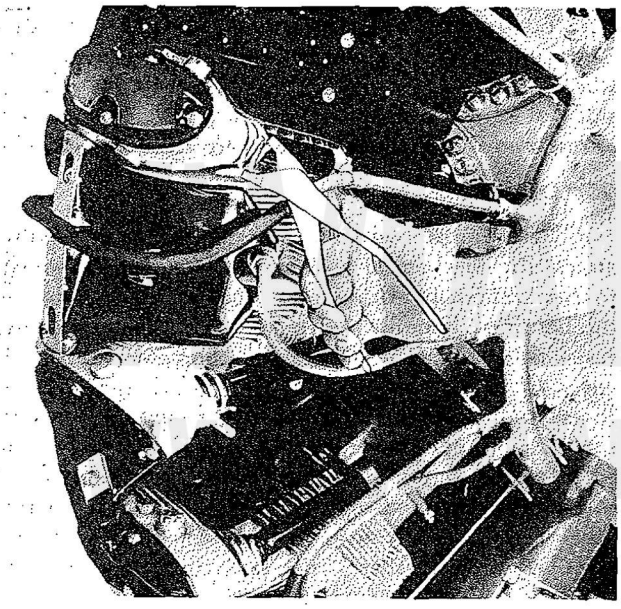

Figure 54—Removing Push Rod Housing Hose Clamp

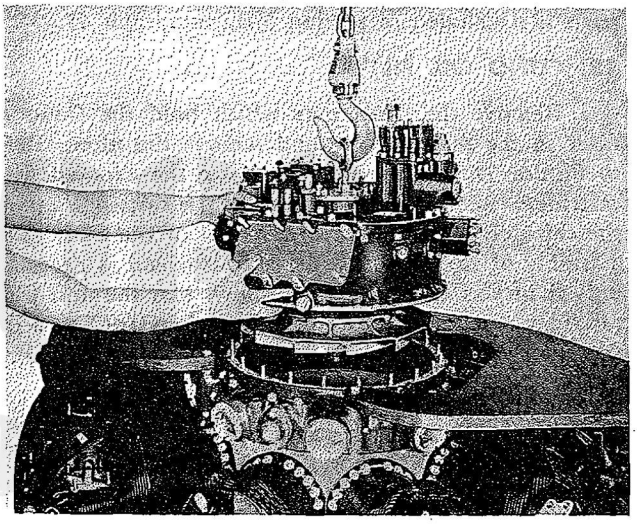

Figure 56—Removing Supercharger Rear Housing and Cover Assembly

and clamps. Discard the hoses. Navy personnel will remove the spring type hose clamp from the hose connections by absorbing the spring pressure with special pliers (Tool No. 800687). Refer to Figure 54.

b. Remove the loose-fitting valve tappet ball sockets and springs from all the valve tappets, turning the crankshaft, if necessary, to push the socket within reach. Place the ball sockets and springs in a box having eighteen individual compartments, one for each tappet and guide assembly, in order that the parts of each assembly may be kept together. Refer to Figure 55.

16. SUPERCHARGER REAR HOUSING AND SUPERCHARGER REAR HOUSING COVER.

a. Turn the mounting plate on the engine disassembly stand until the engine is supported in a front-end-down position, and lock the mounting plate in this position. Remove the nuts and washers which secure the supercharger rear housing to the supercharger front housing. Attach the hoisting eye (Tool No. 83863) to the starter pad on the supercharger rear housing cover, and secure with nuts and washers on all six starter attaching studs. Remove the rear housing and cover assembly. Refer to Figure 56. It may be necessary to tap the rear housing lightly at the parting surface, using a light fibre mallet to separate the two sections. Lower the rear housing and cover

assembly onto a disassembly stand. Refer to Figure 57. A drawing of a disassembly stand which is recommended for use is shown in Figure 58. Remove the hoisting eye from the starter pad.

17. FUEL PUMP DRIVE.

a. Remove the flanged fuel pump drive shaft support, drive shaft, and oil seal as one unit from the rear housing. Two 1/4-20 tapped holes are provided in the flange of the support in which puller screws (Tool No. 84956) may be inserted to facilitate removal of the assembly. Remove the drive shaft from the support. If the shaft can not be removed readily from the support, strike the anti-gear end of the shaft using a fibre drift and mallet. Remove the seal, using removing and installing tool (Tool No. 801534). Do not remove the bushings from the support unless they require replacement. Instructions for replacing these parts are included in Section VII, paragraph 43.

18. CUNO OIL FILTER.

a. Remove the three nuts which hold the Cuno oil filter in the rear housing and remove the filter. Refer to Figure 59. To prevent damaging the exposed filter cartridge, exercise care not to strike the cartridge against the sides of the hole during removal of the filter. Disassembly of the Cuno oil filter at overhaul is necessary only if inspection of the filter shows that the unit filter cartridge must be replaced. Instructions for replacing the filter cartridge are included in Section VII, paragraph 42.

CAUTION

If the Cuno is stuck and cannot be removed easily, tap on each side lightly by using a rawhide mallet. Do not at any time pry the Cuno out of the rear case with a metal object such as a screwdriver or knife.

18A. PRESSURE OIL STRAINER.

a. Break the lockwire and remove the three screws and washers securing the pressure oil strainer assembly to the attaching studs on the left side of the supercharger rear housing.

b. Install puller (Tool No. 923071) and remove the strainer from its cavity. Refer to Figure 59a.

c. Remove the rubber seal ring from the groove on the ID of the strainer cavity in the supercharger rear cover. Refer to figure 59b.

d. Break the lockwire and remove the hex head screw and washer from the hole at the center of the strainer assembly cover, and withdraw the cover. Discard the seal ring located in the small groove on the inside around the center hole in the cover. Slip the screen type strainer from its housing.

19. GUN SYNCHRONIZER.

a. Remove the three cap screws and washers which attach each gun synchronizer impulse generator or gun synchronizer substituting cover to the rear housing, and remove the gun synchronizers or substituting covers. If gun synchronizers were installed, remove the flanged gun synchronizer drive shaft support and drive shaft together from the rear housing after removal of the gun synchronizer.

b. Remove the thread protecting cap and the gun control cable replacement plug, if used, from the upper plunger housing. Remove the three nuts and washers which attach the upper plunger housing to the lower housing, and remove the upper housing and laminated shim. Withdraw the plunger through the slot in the lower housing. Remove the two plugs from the lower housing.

c. Loosen the nut which holds the cam on the drive shaft using wrench (Tool No. 82848). Remove the nut and cam together. Do not separate the cam and nut unless replacement of either part is found to be necessary. Remove the drive shaft from the support.

20. OIL PUMP.

a. Remove the two palnuts, nuts, and washers which attach the mechanical tachometer drive shaft housing to the tachometer drive gear housing cover. Remove the housing. Remove the four palnuts, nuts, and washers which attach the electrical tachometer substituting cover, if used, to the tachometer drive gear housing cover, and remove the substituting cover. Remove the cap screws and washers which attach the tachometer drive gear housing and cover to the oil pump cover, and remove the housing and cover together. Separate these sections and remove the mechanical and electrical tachometer drive shafts, oil seal rings, and oil seal retainers. Withdraw the tachometer drive gear shaft, oil seal ring, and oil seal ring retainer from the oil pump cover. Remove the eight nuts and washers which attach the oil pump cover to the oil pump body and remove the cover. Lift the oil pressure pump drive gear and idler gear out of the oil pump body. Remove the cap screw which secures the lower part of the oil pump body to the rim of the supercharger rear housing cover, using wrench (Tool No. 800684). Remove the oil pump body. Remove the oil pump body end plate, through which the oil pump drive shaft passes, from the oil pump body. Loosen the oil pump drive shaft nut while holding the coupling gear, using wrench (Tool No. 82676). Refer to Figure 60. Remove the nut, washer, oil pump drive coupling, and oil pump drive shaft. Lift the oil suction pump idler gear and shaft out of the oil pump body.

b. Remove the oil pressure relief valve assembly, including the cap, adjusting nut, relief valve washers,

relief valve nut, relief valve spring and valve. Remove the relief valve body, using wrench (Tool No. 803372). Refer to Figure 61.

c. Remove all plugs from the oil pump body. If an oil check valve is used, remove the retainer, spring, and valve with ring. If the oil check valve has been previously removed, remove the packing ring from the recess in the upper left side of the oil pump body where the oil check valve was formerly located. Remove the oil inlet and outlet flanges.

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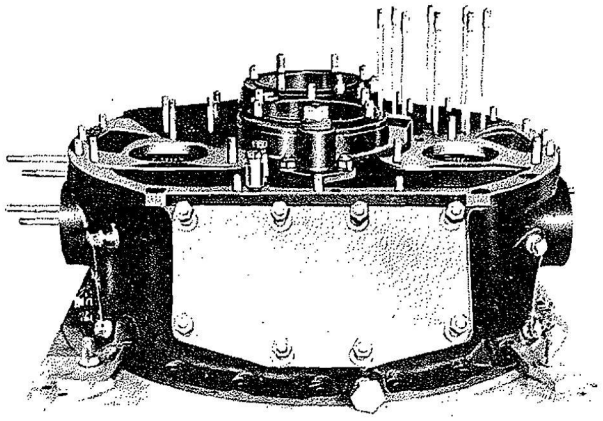

Figure 57—Supercharger Rear Housing on Disassembly Stand

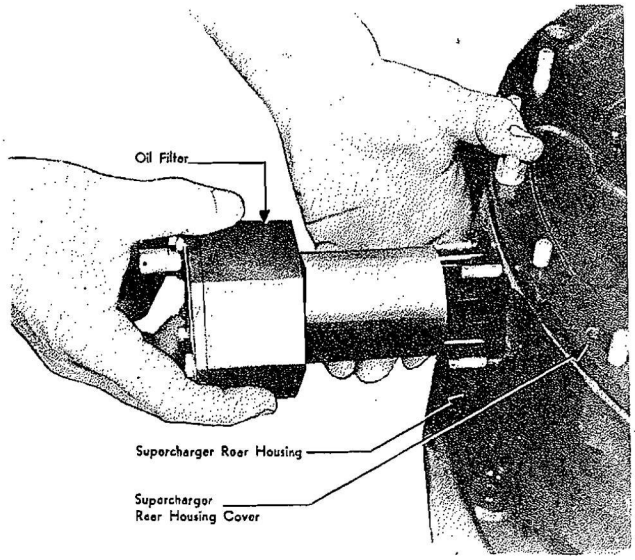

Figure 59—Removing Cuno Oil Filter

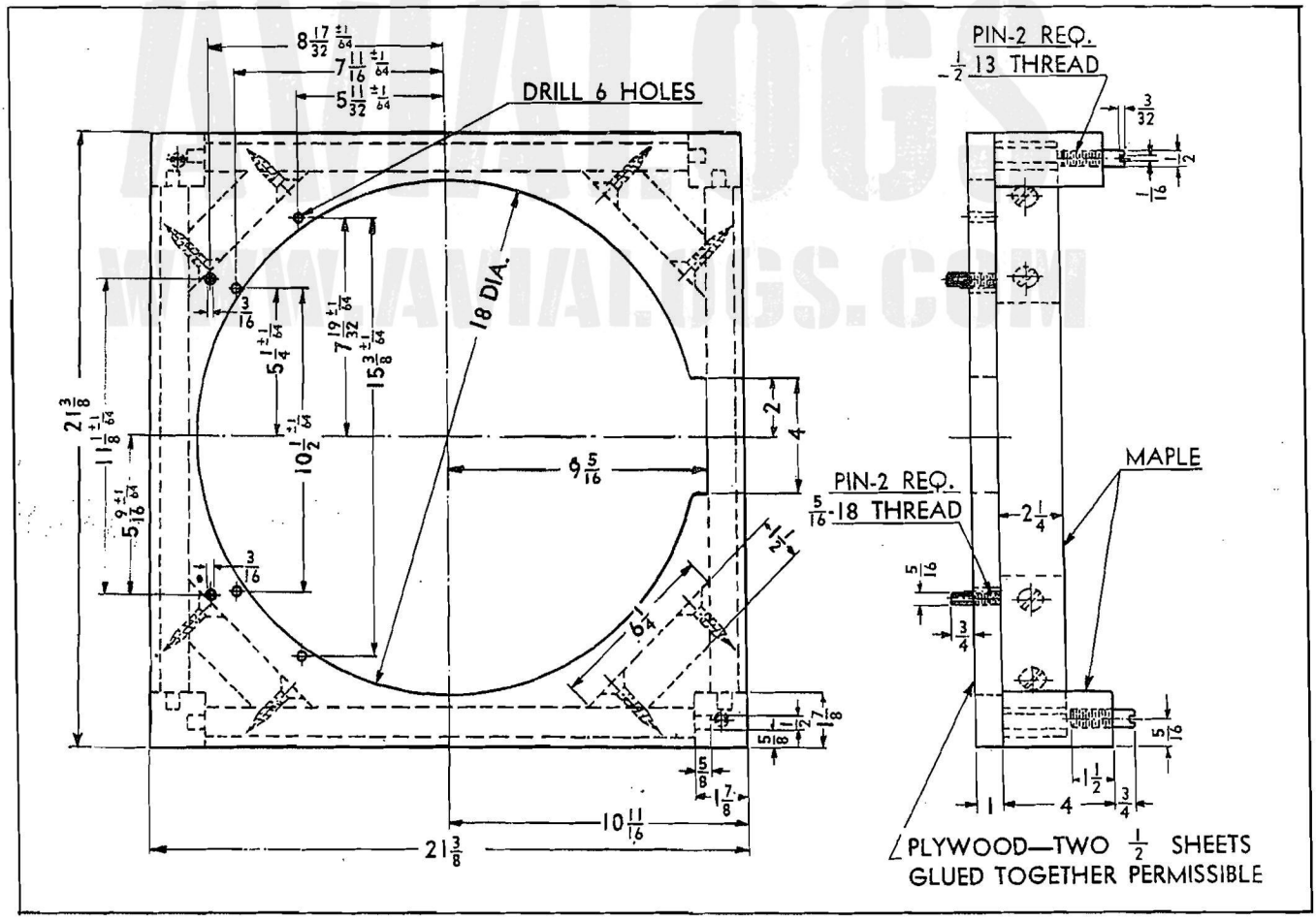

Figure 58—Construction Dimensions for Supercharger Rear Housing Assembly Stand

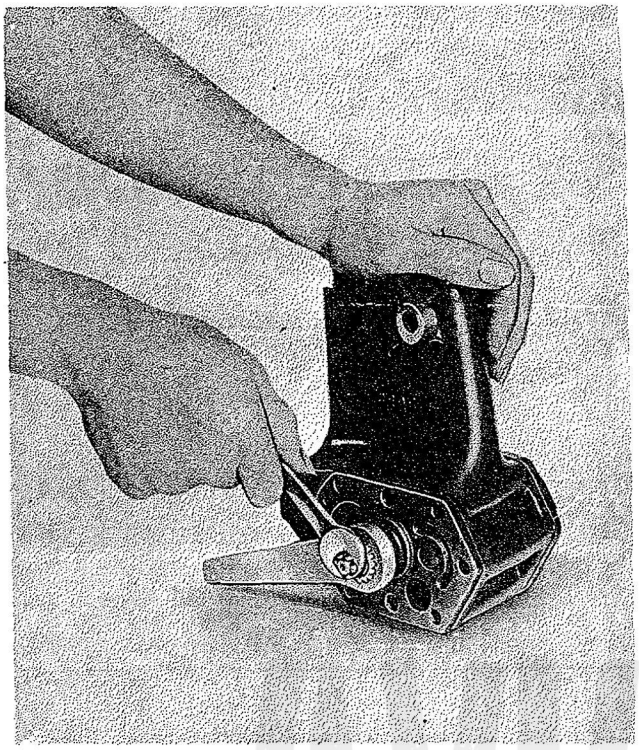

Figure 60—Loosening Oil Pump Shaft Coupling Nut

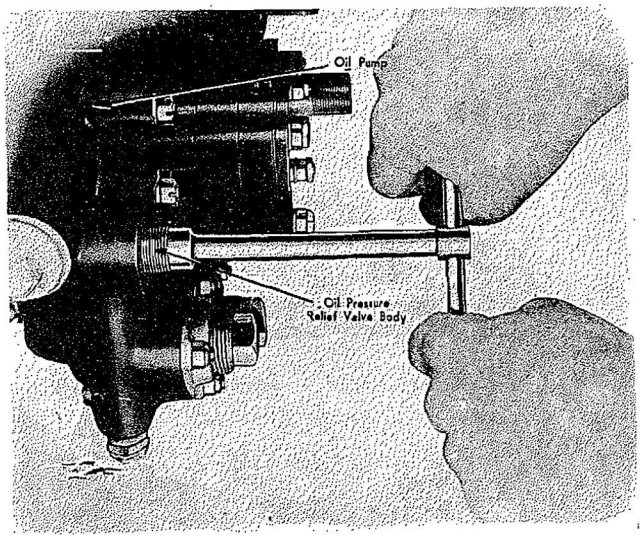

Figure 61—Removing Oil Pressure Relief Valve Body

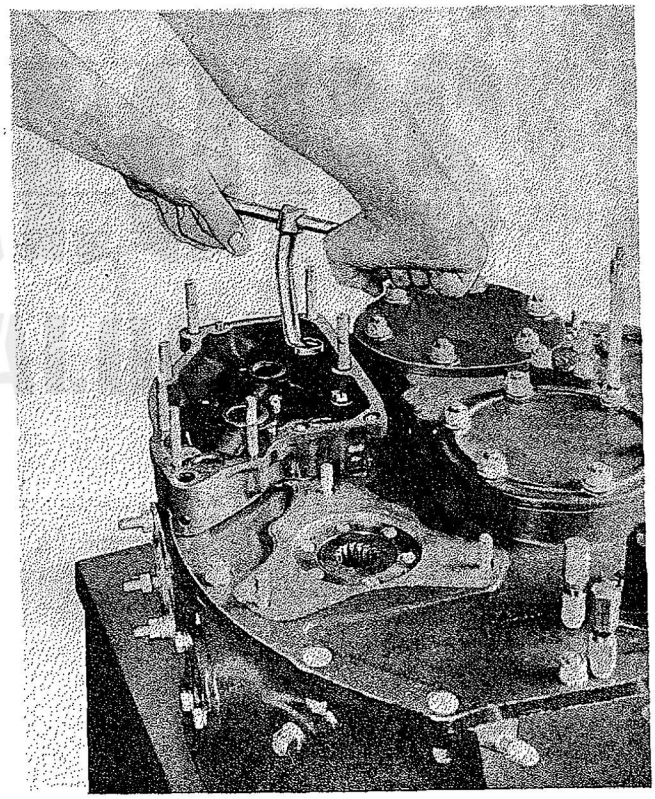

Figure 62—Loosening or Tightening Hidden Nut in Dual Accessory Drive Housing

21. DUAL ACCESSORY DRIVE.

a. Remove the four palnuts, nuts, and washers which attach the lower accessory drive substituting cover, if used, to the dual accessory drive housing cover, and remove the substituting cover. Remove the palnut, nut and washer from the stud located directly to the right of the lower drive. Remove the four palnuts, nuts, and washers which attach the upper accessory drive substituting cover, if used, to the dual accessory drive housing cover, and remove the substituting cover. Remove the two 7/16 in. hexagonal head extended nuts on the upper rim of the dual accessory drive housing cover, and remove the cover. Remove all oil passage plugs from the cover.

b. Lift the upper and lower accessory drive gears, the dual accessory drive idler gear and intermediate gear, bolted together, and the splined main driving gear out of the housing. Disassemble the idler gear and intermediate gear by removing the six cap screws which secure these parts together, using wrench (Tool No. 82914).

c. Remove the nuts and washers in recesses in the dual accessory drive housing, using the offset box wrench (Tool No. 800684) for the two ⅝ in. hexagon nuts. Refer to Figure 62. Remove the extended nut and washer on the rim of the housing at the upper right corner, and the two acorn nuts and washers on the underside of the supercharger rear

housing flange. Remove the dual accessory drive housing. Remove all oil passage plugs from the housing.

22. SUPERCHARGER DRAIN VALVE.

a. Remove the standard type supercharger drain valve assembly from the supercharger rear housing, including the plug, washer, valve housing, disk, gasket, bushing, valve body, washer, and steel venturi tube.

b. Remove the turbo type supercharger drain valve assembly. Break the lock wire securing the valve housing to the supercharger rear housing, and unscrew the valve housing from the valve body. Take care not to drop the piston and disk unit which may remain either with the valve body or in the valve housing. Remove the piston and disk unit. Using the special wrench, unscrew the valve body from the supercharger rear housing, and withdraw the body and tube assembly as a unit.

c. Remove the circlet securing the valve stop and spring in the housing. The valve stop and spring are now free and can be removed. Back out the setscrew in the side of the valve body, and allow the two ball check valves to drop out of the opening vacated by the setscrew. Take care not to drop or lose these balls. Remove the rubber packing rings at each end of the valve body. Do not withdraw the return tube from its seat in the valve body unless it is to be replaced.

23. OIL TANK VENT CONNECTION.

a. Remove the oil tank vent connection from the supercharger rear housing cover.

24. CLUTCH CONTROL VALVE OR SUBSTITUTING COVER.

a. Remove the three palnuts, nuts, and washers which attach the two-speed clutch control valve substituting cover to the rear side of the supercharger rear housing cover and remove the substituting cover.

b. On two-speed engines, remove the three nuts, palnuts, and washers which attach the two-speed clutch control valve housing to the rear side of the rear cover, and remove the valve assembly. Remove the nut on the threaded end of the valve and remove the valve, spring, washer, and packing from the housing. Discard the packing. Withdraw the oil control valve sleeve from the rear cover.

25. STARTER SHAFT OIL SEAL.

a. Remove the twelve accessory drive and starter shaft oil seal packing retainer screws. Some engines use fillister head screws, locked by shakeproof lock washers, in this location. Engines of current manufacture use flat head screws, locked by staking into a groove in the retainer attaching flange. The flat head screws may be best removed by inserting a screw driver squarely in the screw slot, rapping the end of the screw driver sharply, using a fiber mallet to loosen the screw, and then removing the screw using the screw driver. Tighten three screws having a No. 10-32 thread into the three tapped holes in the retainer to remove the retainer. Remove the oilite packing, starter dog, and aluminum spacer.

26. GENERATOR AND MAGNETO DRIVE OIL SEALS.

a. Remove the generator substituting cover. Remove the six fillister head screws and shakeproof lock washers which attach the generator drive oil seal retainer to the rear cover. Tighten two screws having a No. 10-32 thread into the two tapped holes in the retainer to remove the retainer. Remove the generator drive oil seal collar, using puller (Tool No. 84983). Refer to Figure 63. Remove the oilite seal, diaphragm,

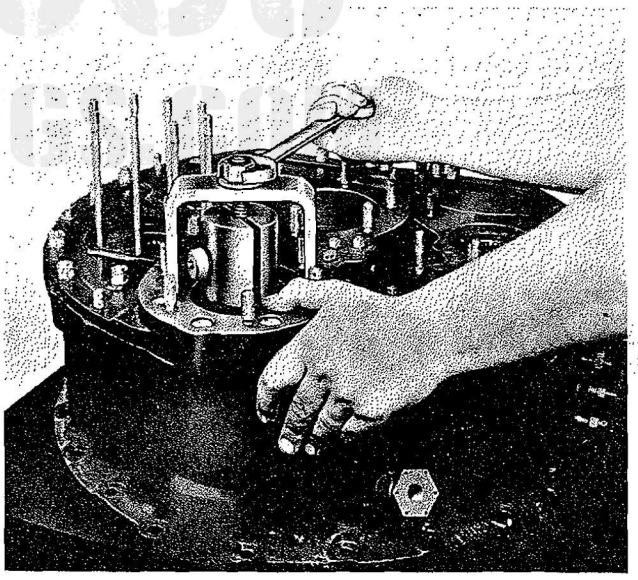

Figure 63—Removing Generator Drive Oil Seal Collar

flanged thrust washer, and spring. Discard the diaphragm. Remove the corresponding parts from the two magneto drive oil seals in the same manner, using the same puller. Refer to Figures 64 and 65. Discard the diaphragm from these seals.

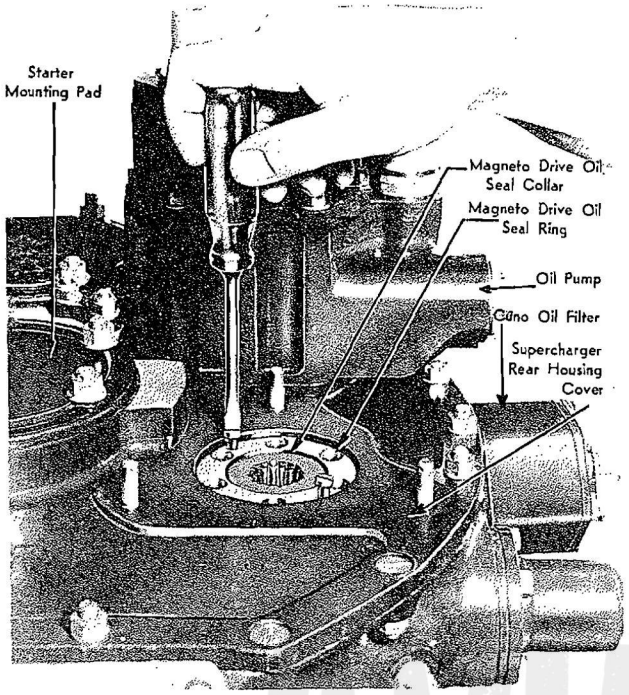

Figure 64—Removing Magneto Drive Oil Seal Ring

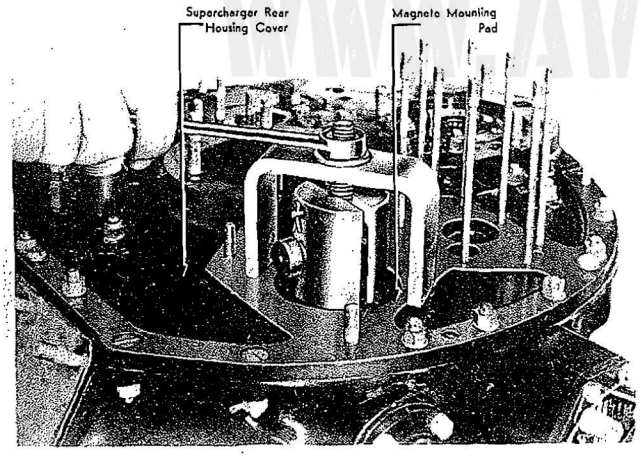

Figure 65—Removing Magneto Oil Seal Collar

27. SUPERCHARGER REAR HOUSING COVER.

a. Remove all gaskets remaining on the supercharger rear housing cover. Remove all palnuts, nuts, washers, and machine screws from the rim of the rear cover. Refer to Figure 66. Remove the magneto conduit attaching bracket. Remove the three slotted

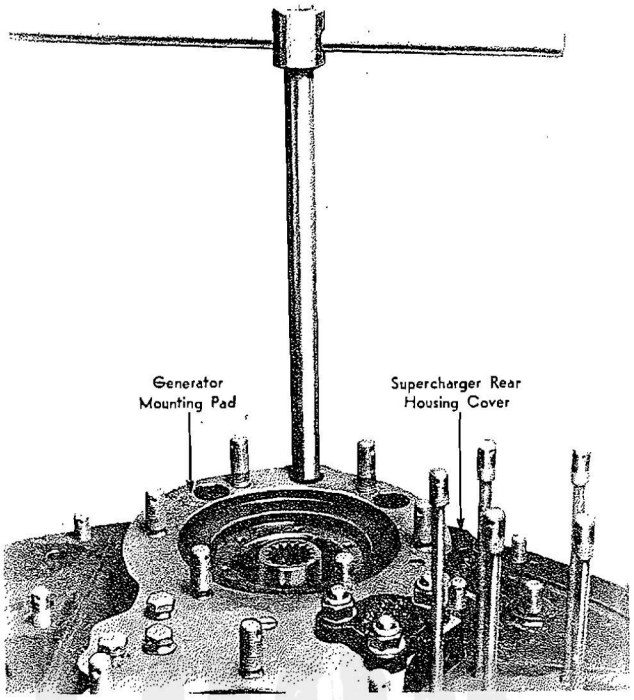

Figure 66—Removing or Installing Slotted Round Nut in Supercharger Rear Housing Cover

round nuts under the generator mounting pad, using lug wrench (Tool No. 83381). Remove the three puller hole plugs and gaskets from the rim of the rear cover, and insert in their place three pullers (Tool No. 83648). Screw down evenly on the pullers to remove the rear cover. Refer to Figure 67. If necessary, tap the edge of the rear cover lightly, using a fiber mallet to separate the cover from the housing. If it appears that too much force on the pullers is required to remove the cover, check again to insure that all attaching nuts and screws have been removed. Continue turning down evenly on the pullers until the cover is loose on the rear housing. Before lifting off the rear cover, check to insure that all the accessory drive gears will remain in the rear housing. If the magneto or generator drive shafts have remained in the rear cover, tap the end of the shafts, using a fiber drift and mallet until the shafts drop into the rear housing. If it is necessary to tap the generator drive gear shaft out of the rear cover, take care to insure that the drift bears on the exposed end of the shaft and does not slip intside the shaft, since that might drive out the generator drive gear cup plug which is pressed into the front end of the shaft. Lift off the rear cover, and remove the pullers.

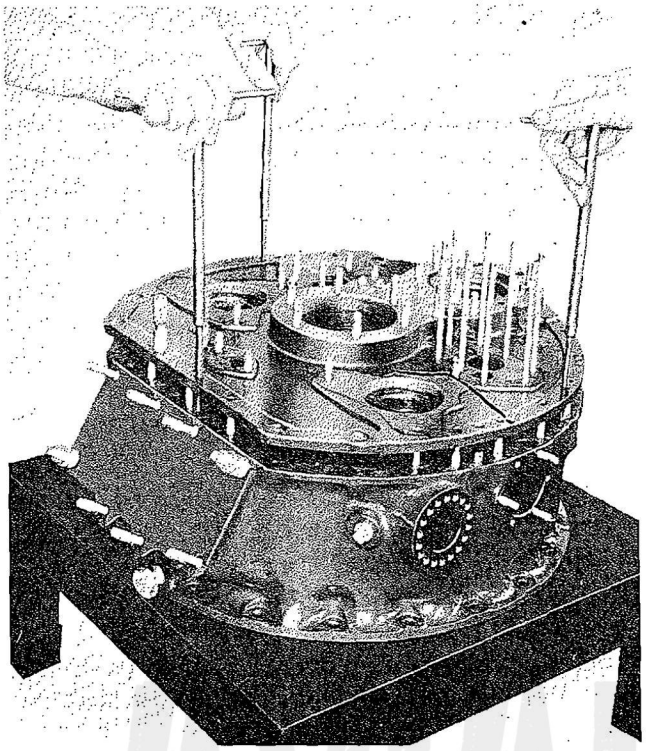

Figure 67—Removing Supercharger Rear Housing Cover

b. Do not remove the engine oil pressure gage tube which leads from the accessory drive and starter shaft bushing to the oil pressure gage connection in the rear cover.

28. SINGLE-SPEED IMPELLER DRIVE.

a. In engines equipped with a single speed impeller drive, proceed with the disassembly as follows: Lift all the accessory driving gears out of the supercharger rear housing. Disassemble the magneto drive gears and the dual accessory drive gear from their respective shafts by removing the attaching screws. Lift out the accessory drive and starter shaft, taking care to insure that the splines on the front end of the shaft do not scratch or score the impeller shaft bushings. Remove the bronze thrust ring from the recess in the impeller shaft retainer. Remove the five screws which attach the accessory drive gear rear plate to the shaft, and remove the plate. Before disassembling the springs and retaining pins from the shaft, observe the following precaution: Wrap a heavy cloth tightly around the accessory drive gear and rear end of the shaft, so that when the springs are driven out of the shaft they will not be free to fly out and possibly cause injury to shop personnel, but will be contained inside the cloth wrapping. Stand the shaft on the disassembly bench, rear end down, and drive out the springs and retaining pins by striking the springs lightly, using a mallet. Remove the cloth from the shaft. Remove the gear by turning approximately 30 deg to disengage the internal lugs on the gear from the mating ears on the shaft.

b. Remove the five flat head screws which secure the impeller shaft retainer to the rear housing. To do this, insert a screw driver squarely in the screw slot, rap the end of the screw driver sharply, using a fiber mallet to loosen the screw, and remove the screw. Remove the retainer and ring, the shim, the spherical thrust ring, and the steel washer. Remove the ring from the retainer and discard the ring.

c. Lift the impeller drive gear and pinion out of the supercharger rear housing.

29. TWO-SPEED IMPELLER DRIVE (PLATE CLUTCH TYPE).

a. In engines equipped with a two-speed impeller drive of the plate clutch type, proceed with the disassembly as follows, after removal of the supercharger rear housing cover: Remove the six nuts and washers which attach the low-speed clutch housing to the front side of the supercharger rear housing cover. Hold the housing down firmly against the tension of the low-speed clutch release spring by hand while removing the last two nuts from the housing. Remove the housing, sun gear, clutch disk and plates, thrust washer and spacer, spring, piston with ring, and sleeve. Do not attempt to remove the low-speed clutch piston lock from the piston. If either of these parts requires replacement, the entire assembly must be replaced. The low-speed clutch piston and lock may only be procured together in a matched assembly. Remove the ring from the piston and discard the ring.

b. Withdraw the intermediate impeller drive shaft and pinion assembly and bell-shaped intermediate impeller drive gear as one unit from the high-speed clutch assembly into which it is splined. Remove the bell-shaped drive gear from the shaft. Remove the small horseshoe-shaped pinion gear retaining washers from the pinion trunnions, and remove the pinions and floating pinion bushings. Remove the shouldered sun gear floating bushing from the shaft.

c. Lift out the high-speed clutch release spring.

d. Lift all the accessory driving gears out of the supercharger rear housing. Disassemble the magneto drive gears and the dual accessory drive gear from their respective shafts by removing the attaching screws. Remove and disassemble the accessory drive and starter shaft in the same manner as described previously for engines having a single-speed impeller drive. Remove the bronze thrust ring from the recess in the impeller shaft retainer. Remove the five flat head screws which secure the impeller shaft retainer to the rear housing. Remove the retainer and ring, the shim, the spherical thrust ring, and the splined washer. Remove and discard the retainer oil seal ring.

e. Lift the impeller drive gear, containing the high-speed clutch assembly, out of the rear housing. Clamp the holding fixture (Tool No. 84668) vertically in a vise, and place the gear in the fixture. Lock the gear in place by tightening the set screw in the fixture. Cut off one bent-up end of the spring steel wire which holds the high-speed clutch assembly in the gear. Grasp the other end of the wire and pull it clear of the gear. Refer to Figure 68. Discard the wire. Remove the gear from the fixture, and remove the clutch retainer disk and plates, the splined adapter, and the piston with ring. Remove and discard the piston ring.

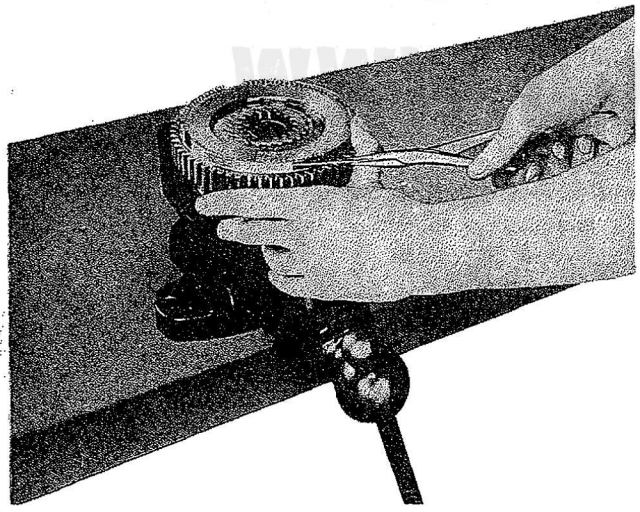

Figure 68—Removing Spring Steel Wire From the High Speed Clutch Assembly

30. TWO-SPEED IMPELLER DRIVE (ROLLER CLUTCH TYPE).

a. In engines equipped with a two-speed impeller drive of the roller clutch type, proceed with the disassembly as follows, after having removed the supercharger rear housing cover: Disassemble the high ratio clutch which is secured to the front of the supercharger rear housing cover. To accomplish this, remove the six cotterpins, nuts, and flat washers which secure the clutch housing to the rear cover. While removing the last two nuts from the housing, press down firmly on the housing to counteract the force exerted by the clutch release spring. Remove the high speed clutch housing and intermediate clutch adapter. Remove the thrust washer, spacer, spring, clutch plates and disks, and the piston with its ring. Remove the ring from the piston and discard the ring. Remove the high ratio impeller drive clutch sleeve with puller (Tool No. 802571).

b. Remove the roller retainer and cam assembly from the intermediate impeller drive shaft. Lift all the accessory driving gears out of the supercharger rear housing and disassemble these gears as described previously for single speed engines. Remove the bronze thrust ring from the recess in the impeller shaft retainer. Remove the five flat head screws which secure the impeller shaft retainer to the rear housing. Remove the retainer and ring, the shim, the spherical thrust ring, and the splined washer. Remove and discard the retainer oil seal ring.

c. Remove the remainder of the two-speed clutch assembly as a unit from the supercharger rear housing. Disassemble these parts by first removing the intermediate impeller drive gear and its internal bushing. Remove the intermediate impeller drive shaft and pinion cage assembly from the impeller drive gear. Remove four cap screws holding the front and rear halves of the pinion cage together and lift off the rear half of the pinion cage. Withdraw the intermediate impeller drive shaft and remove the pinions and bushings from the front half of the pinion cage. Place part in rack. Refer to Figure 69.

31. IMPELLER AND IMPELLER SHAFT.

a. Complete the disassembly of the supercharger rear housing in all engines as follows: Place the rear housing, with the diffuser plate up, on a bench which is covered with a fiber pad larger in diameter than the rear housing. The fiber pad and bench should have holes drilled in locations corresponding to the stud locations on the antipropeller side of the rear housing. The drilled holes should be large enough in diameter and depth to accommodate the rear housing studs. Place the rear housing on the bench so that

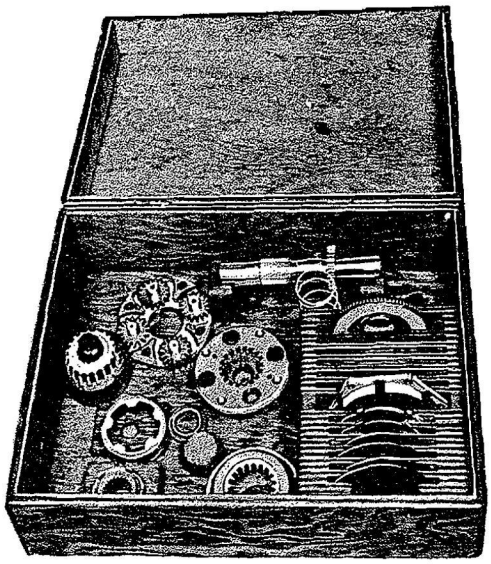

Figure 69—Roller Clutch Parts Rack

the studs project into the drilled holes and so that the rear housing rests on the rear cover parting surface. This procedure insures that the studs will not be damaged during the following operations. Clamp the rear housing tightly to the bench in this position. Place strips of light cardboard between the impeller vanes and the diffuser plate to protect these parts during the following operations.

b. Bend the tab of the impeller nut lock out of the slot in the nut. Install the impeller holding tool (Tool No. 802395) and adapter (Tool No. 84534) on the supercharger rear housing. With the impeller locked firmly, remove the impeller nut using lug wrench

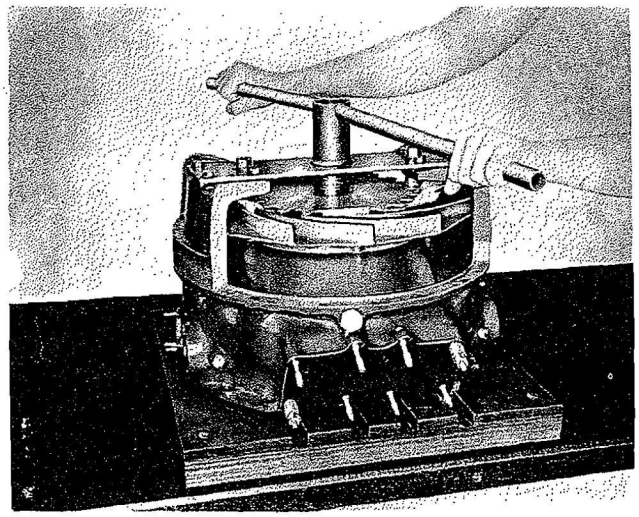

Figure 70—Loosening or Tightening Impeller Nut

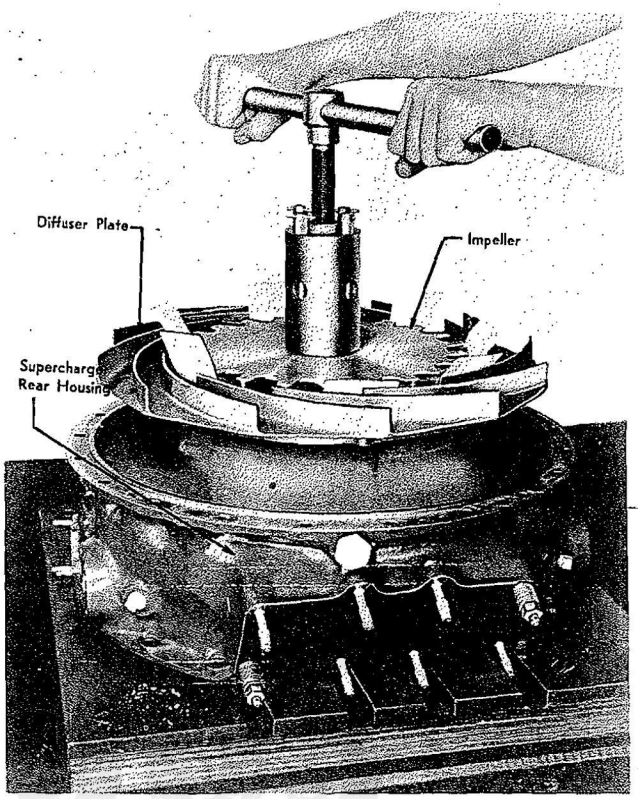

Figure 71—Removing or Installing Impeller

(Tool No. 802275. Refer to Figure 70. Remove the impeller nut lock and the front impeller shaft oil sleeve with rings. Remove the oil seal rings from the sleeve and discard the rings. Remove the impeller locking tool and adapter. Remove the impeller from the impeller shaft using puller (Tool No. 800304). Refer to Figure 71. Place impeller in box as shown in Figure 72. After removal of the impeller, remove the impeller shaft from the rear housing. Remove the rear impeller shaft oil sleeve with rings and the bronze washer from the impeller shaft. Remove and discard the oil seal rings. If it is necessary to replace impeller drive shaft rear centering ring washer, use puller (Tool No. 803639) and adapter (Tool No. 803640), or puller (Tool No. 800819.)

c. Remove the plate covering the entrance to the induction passage in the supercharger rear housing.

d. Do not remove the manifold pressure gage tube which crosses the induction passage in the rear housing. Do not remove the copper fuel venturi extension tube which is spun into the lower part of the rear housing. Instructions for replacing the spun-in fuel

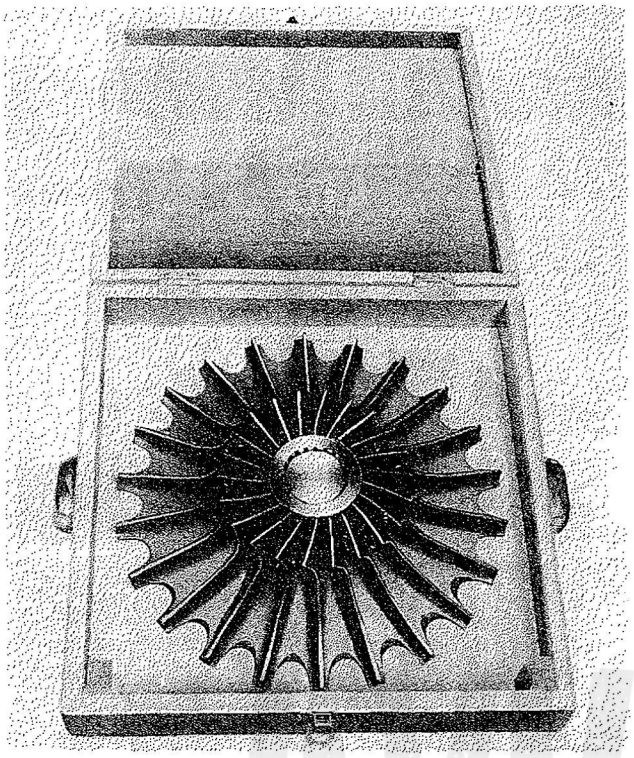

Figure 72—Impeller Storage Box

venturi extension tube if the tube is found to be loose are included in Section VII, paragraph 30 b.

e. Do not remove the diffuser plate from the supercharger rear housing unless inspection indicates that replacement of the diffuser plate is necessary. Instructions for removing the diffuser plate for replacement with a new part are included in Section VII, paragraph 30 c.

32. CYLINDERS.

a. Turn the mounting plate until the engine is supported in the front-end-up position, and lock the mounting plate in this position. Begin the removal of the cylinders with a cylinder adjacent to the master rod cylinder. Turn the crankshaft using turning tool (Tool No. 82284), installed on the propeller shaft splines, and two handles (Tool No. 80292) until the piston in the cylinder being removed is at the top of its stroke.

WARNING

It is important that the master rod cylinder be removed last. Refer to the engine data plate for the location of the cylinder in which the master rod is located.

b. Remove the lockwire from the cylinder hold-down cap screws attaching the cylinder which is being removed, to the crankcase. Loosen the cap screws using wrench (Tool No. 82750) for 9/16 in. hexagonal cap screws or wrench (Tool No. 82860) for 1/2 in. hexagonal cap screws. Refer to Figure 73. Remove the

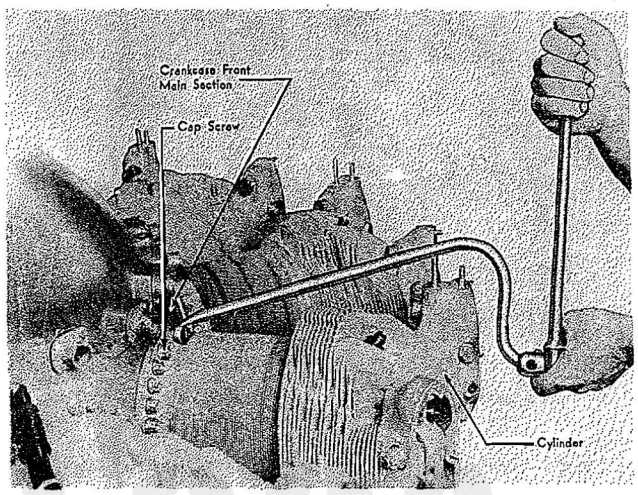

Figure 73—Removing Cylinder Hold-Down Cap Screw

cap screws and spherical seat washers from the cylinder flange. Speed wrench (Tool No. 83131) is recommended for the removal of 9/16 in. hexagonal cylinder hold-down cap screws after loosening. Speed wrench (Tool No. 83130) is similarly recommended for 1/2 in. hexagon cap screws. Remove the cylinder by pulling out straight until it is clear of the piston. Refer to Figure 74. When the piston assembly incorporates the aluminum plug piston pin retainers they

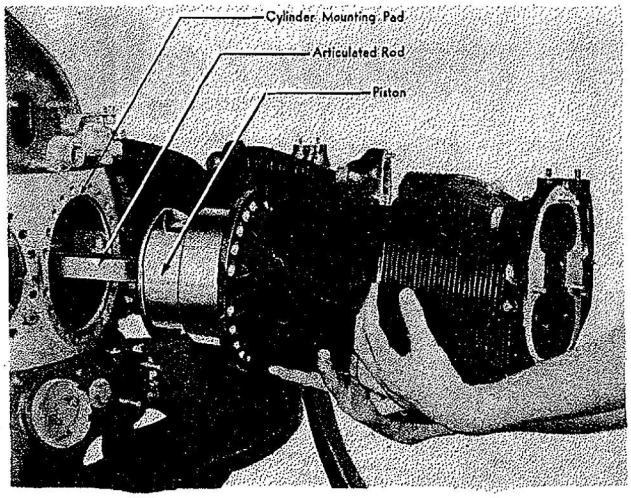

Figure 74—Removing Cylinder

are held in position by the cylinder wall. When the cylinder is withdrawn from the piston the retainer plugs must be supported. The piston assembly must be removed from the connecting rod immediately after the removal of each cylinder. Clamp a cylinder fin

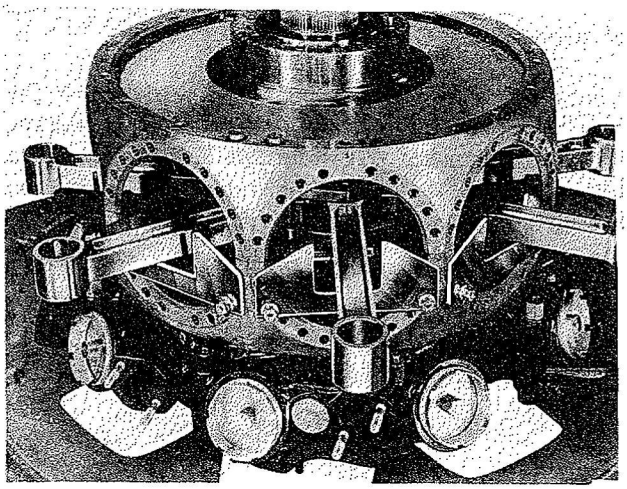

Figure 75—Location of Articulated Rod Protectors

protector (Tool No. 800259) around the cylinder head to protect the lower cylinder head fins. Install a connecting rod protector (Tool No. 83596) on the cylinder pad, attaching it temporarily with two cap screws, to prevent the rod from striking the crankcase. Refer to Figure 75.

33. PISTON PIN RETAINERS.

a. When the piston assembly incorporates the coil spring type retainers, remove them with the retainer spring removing tool (Tool No. 84377). Insert the hook on the tool between two of the spring coils at a point on the centerline of the piston pin hole nearest the crankshaft. Turn the handle of the tool 90 deg to engage the ears of the hook with the spring coils, rest the aluminum fulcrum block on the piston skirt and apply pressure on the handle of the tool in the direction of the crankshaft to remove the retainer. Refer to Figure 76. When removing a retainer, place one hand over the piston pin hole to catch the spring when it comes out of its groove. Discard all used spring type piston pin retainers.

34. PISTON PINS.

a. Remove the piston pins. When the piston pin is a tight fit in the piston, use the piston pin removing tool (Tool No. 804868). Place piston pins in rack similar to that shown in Figure 78.

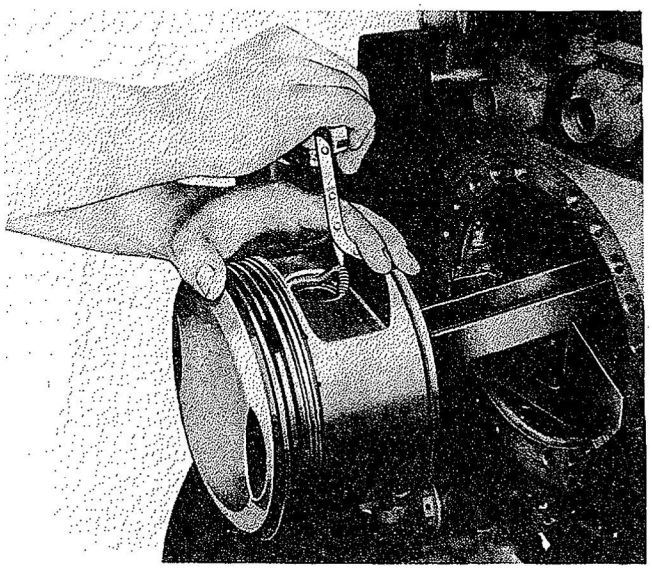

Figure 76—Removing Piston Pin Retainer

35. PISTONS AND PISTON RINGS.

a. Lift the piston off the connecting rod after removal of the piston pin. Remove and discard the piston rings.

b. Remove the remaining cylinders and pistons individually, starting with the cylinder adjacent to the cylinder just removed in the direction *away from* the master rod cylinder, in the same manner as previously

Figure 77 Deleted in Revision

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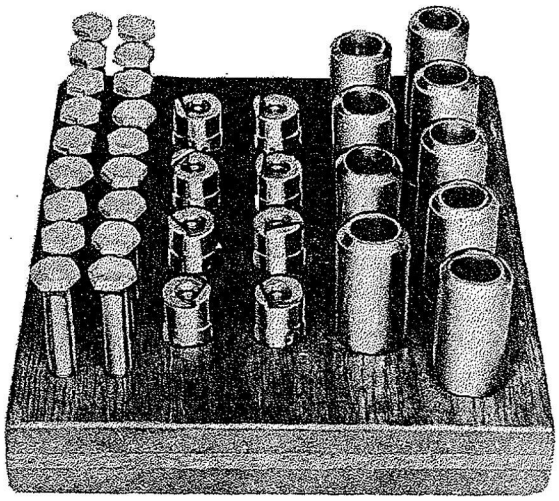

Figure 78—Piston Pin and Knuckle Pin Rack

described. Each time, turn the crankshaft until the piston in the cylinder to be removed is at the top of its stroke before removing the cylinder hold-down cap screws. Remove the master rod cylinder and piston last. Place the pistons on a rack similar to that shown in Figure 79.

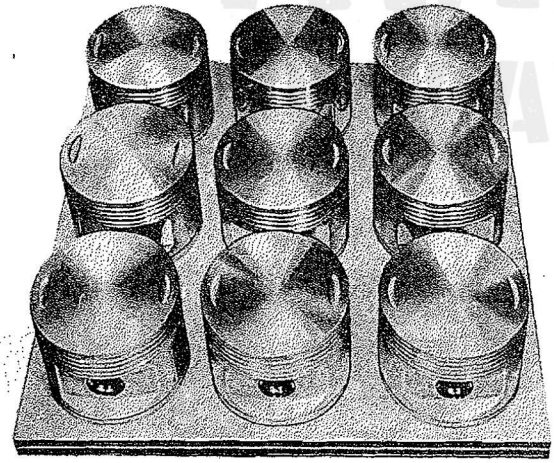

Figure 79—Piston Rack

36. VALVES AND VALVE SPRINGS.

a. Place a cylinder on a valve assembly and disassembly stand (Tool No. 80262). To loosen the carbon around the valve locks and in the lock grooves, procure a fiber drift of circular cross-section approximately 1¼ in. in diameter. Place one end of the drift on the top center of the valve spring upper washer, hold the drift in a position concentric with the valve stem, and strike the drift squarely on the other end to loosen accumulated carbon. These precautions are necessary in order that the valve spring upper washer will not be cocked when struck, as this may cause serious nicking of the valve stem by the bottom edge of the washer.

b. Install the valve spring compressor (Tool No. 81409) in place, and insert the rod attached to the tool through the rocker arm hub bolt hole in the rocker box. Compress the springs and remove the split locks. Refer to Figure 80. Remove the compressor and lift

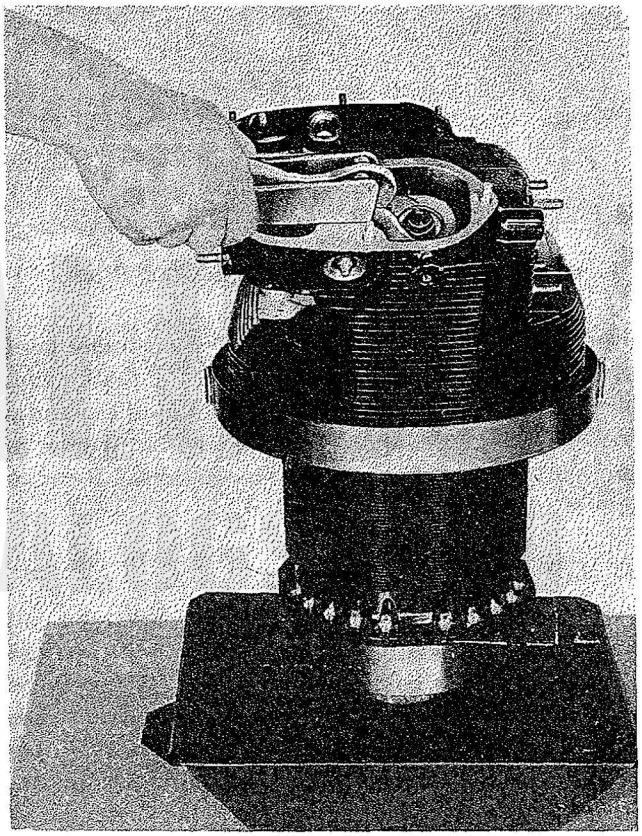

Figure 80—Removing Split Valve Locks Using Valve Spring Compressor

out the valve spring upper washer, valve springs, and lower washers. Place springs in rack as shown in Figure 81.

c. Remove the corresponding parts from the other rocker box in the cylinder in the same manner. Before lifting the cylinder off the holding block, determine if the valve stems are nicked or burred. If any nicks or burrs are present, they should be removed by polishing before removing the valves, since a nick or burr

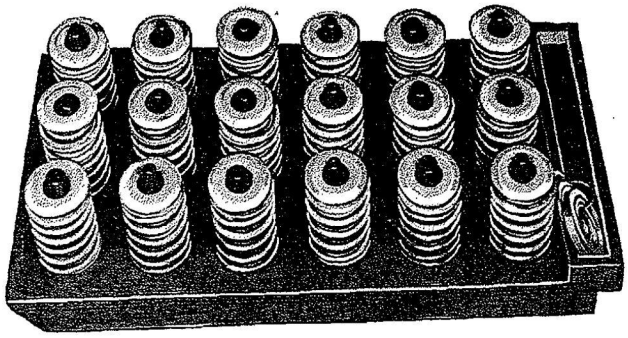

Figure 81—Valve Spring Rack

on the valve stem may scratch or score the valve guide upon removal of the valve. Remove the cylinder from the block, while holding the valves to prevent them from falling out of the guides. Lay the cylinder on its side and remove the valves. Place valves in rack. Refer to Figure 83. Remove the intake port cover (Tool No. 800909) and the exhaust port cover (Tool No. 800910) from the cylinder. Remove the dummy spark plugs.

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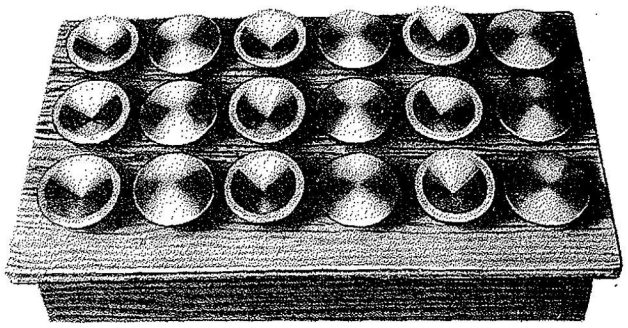

Figure 83—Valve Rack

d. Repeat these operations on all cylinders.

37. VALVE TAPPETS AND VALVE TAPPET GUIDES.

a. With the engine supported in a front-end-up position and the mounting plate locked in that position, remove the palnuts, nuts, and washers from the two tappet guide attaching studs in each tappet guide location, and remove all valve tappet and guide assemblies from the crankcase front section. If a guide cannot be removed by hand, use puller (Tool No. 802242) and adapter (Tool No. 802726) for this purpose. This puller is provided with a rod which is clamped at one end to the guide. A weight is installed on the rod. Removal of a tight-fitting guide is accomplished by sliding the weight along the rod until it contacts a stop on the outer end of the rod to provide the necessary inertia. Refer to Figure 84.

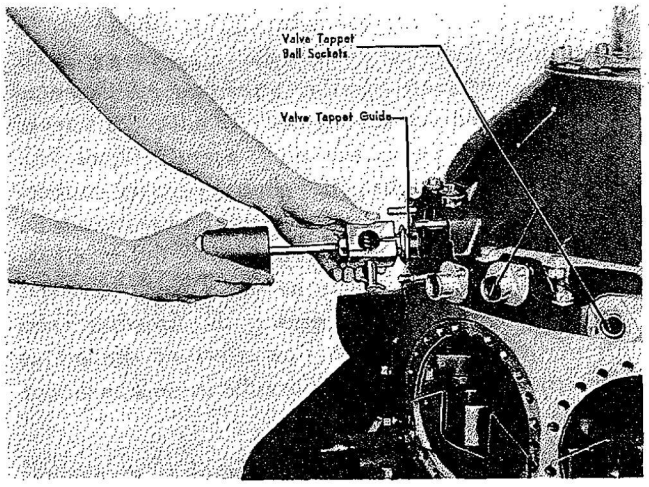

Figure 84—Removing Tight Fitting Valve Tappet Guides

b. Remove the valve tappet circlet from each assembly by inserting the hooked end of the valve tappet circlet removing tool (Tool No. 800087) under the circlet, and pulling out the circlets. Refer to Figure 85. Do not attempt to remove the circlets by any other means. Discard the circlets. Push the floating pin out

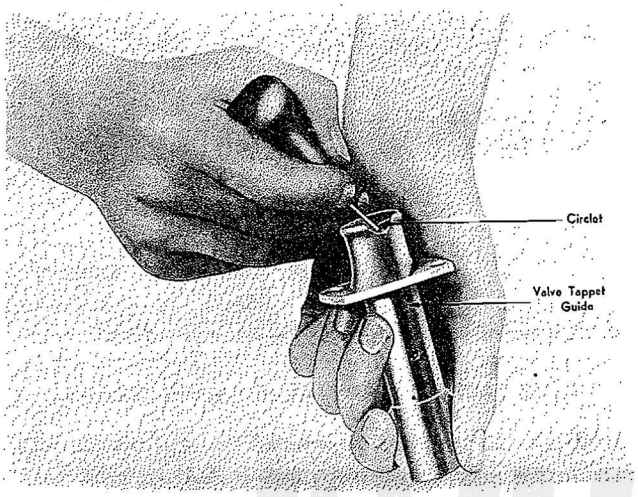

Figure 85—Removing Valve Tappet Retaining Circlet

of the slotted end of the tappet, and remove the bushing and roller. Place the valve tappets and guides, pins, rollers, and bushings in the box with the valve tappet ball sockets and springs which were previously removed to insure that the matched parts of each assembly are kept together.

38. CRANKSHAFT BREATHER TUBE.

a. In engines provided with a crankshaft breather tube, remove the breather tube at this time. To do this, break the lockwire locking the three screws which secure the crankshaft breather screen to the breather tube nut and remove the screws. Remove the screen. Remove the nut using the plug wrench (Tool No. 82195). Remove the propeller shaft hydro-oil connection or cover, whichever is used, and the breather tube front gasket. Remove the breather tube and rear gasket. The breather tube may be more easily removed with a rotating motion. Turning the breather tube helps to overcome the adhesive effect of the oil at the breather tube support. Place tube in rack as shown in Figure 86.

b. In engines which do not employ crankshaft breathing, remove the three screws which secure the propeller shaft front nut lock to the nut. Remove

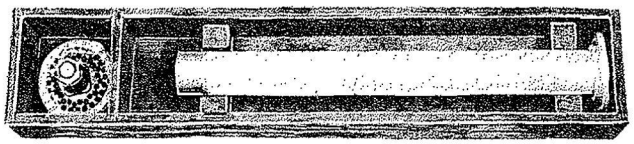

Figure 86—Breather Tube Rack

the lock. Remove the nut using wrench (Tool No. 82195). Remove the propeller shaft hydro-oil connection or cover, whichever is used, and front gasket. Remove the adapter and gasket.

c. Break the lockwire on the cap screws which secure the crankcase front section to the crankcase front main section. Remove the cap screws and washers. Remove the four ignition wiring manifold supports.

d. Remove the three puller hole plugs and gaskets from the rim of the crankcase front section, insert in their place three pullers (Tool No. 83648). Screw down evenly on the pullers until the front section is loose on the crankcase front main section. Refer to Figure 87. Install the hoisting eye (Tool No. 83761)

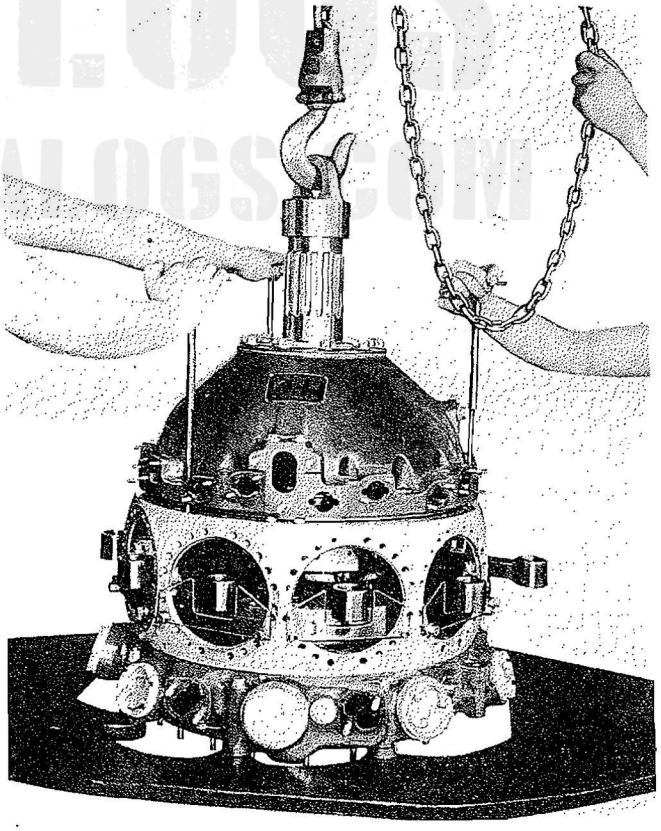

Figure 87—Removing Crankcase Front Section

on the propeller shaft threads. With the hook on the chain hoist inserted through the hoisting eye, raise the front section until it clears the crankshaft front extension. Refer to Figure 88. Insert three crankcase

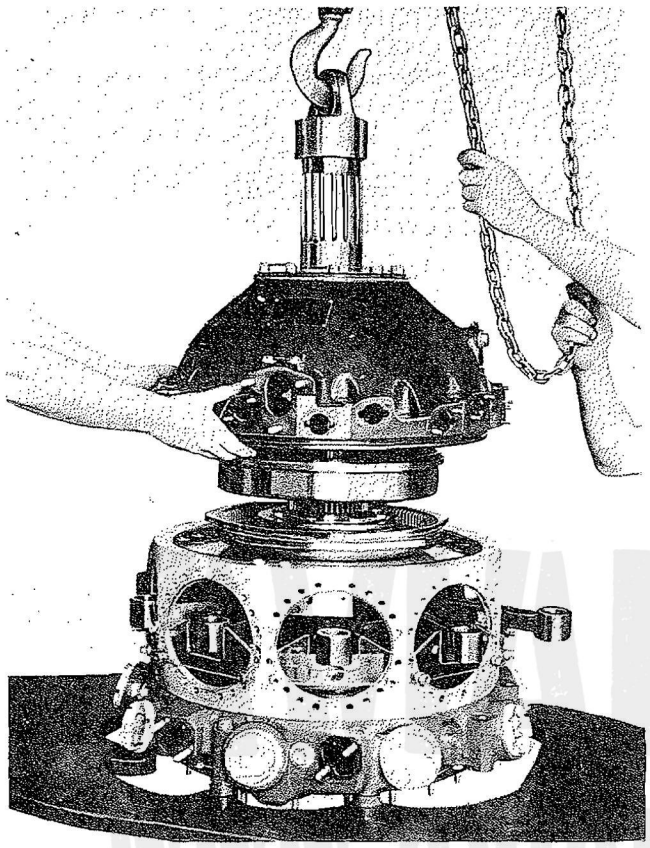

Figure 88—Raising or Lowering Crankcase Front Section

parting flange protectors (Tool No. 801789) on flange. Lower the front section onto a bench. Remove the pullers and hoisting eye. Reinstall the puller hole plugs and gaskets in the crankcase front section to prevent loss.

39. THRUST NUT.

With the crankcase front section on a bench, propeller shaft pointing upward, unscrew the thrust bearing nut using wrench (Tool No. 82889). This nut should have been loosened when the engine disassembly was begun. Remove the nut and oil seal rings. Discard the rings.

40. CRANKCASE FRONT SECTION SPACER AND FLANGE.

The crankcase front section spacer and flange are attached to the crankcase front section by ten nuts and washers in .666 (3:2) reduction geared engines, and by ten cap screws and washers in .5625 (16:9) reduction geared and direct drive engines. Break the lockwire from the attaching nuts or cap screws, and remove the nuts, or cap screws, and washers. Remove the aluminum crankcase front section spacer.

41. THRUST BEARING.

a. In engines provided with a .666 (3:2) reduction gear, proceed with the disassembly of the crankcase front section as follows, after removal of the front section spacer and flange: Turn the crankcase front section over so that the propeller shaft points downward, projecting through a hole approximately 5 in. in diameter cut in the bench. Break the lockwire from the two remaining nuts which attach the stationary reduction gear to the interior of the front section, and remove the nuts using a socket wrench. It may be necessary to turn the propeller shaft in order to obtain access to these nuts between the pinion spider arms. Turn the crankcase front section over so that the propeller shaft points upward, and place the entire assembly on an assembly and disassembly block. Figure 89 shows the dimensions of a block recommended for use. The pilot on the top of the block fits in the propeller shaft rear bushing. Remove and discard the circlets from the eight bolts which project through the crankcase front section. Remove the steel flange.

b. In engines provided with a .5625 (16:9) reduction gear, or direct drive, proceed with the disassembly of the crankcase front section as follows, after removal of the front section spacer and flange: Place the entire assembly on the assembly and disassembly block. Remove the two remaining cap screws which attach the stationary reduction gear support or oil seal sleeve support to the front section. These two cap screws are in counterbored holes in the front section, under the front section flange.

c. The following instructions for removal of the thrust bearing apply to reduction geared as well as direct drive engines: Lift the crankcase front section off the propeller shaft. The thrust bearing is a tight fit on the propeller shaft and will remain on the shaft. Install the thrust bearing puller (Tool No. 800377) and the halves of the split adapter (Tool No. 800378) on the thrust bearing, locking the tools in place on the bearing with the collar on the puller. Turn the puller handle to raise the puller screw. In engines provided with a thrust bearing having a solid inner race, this will remove the entire bearing. In engines

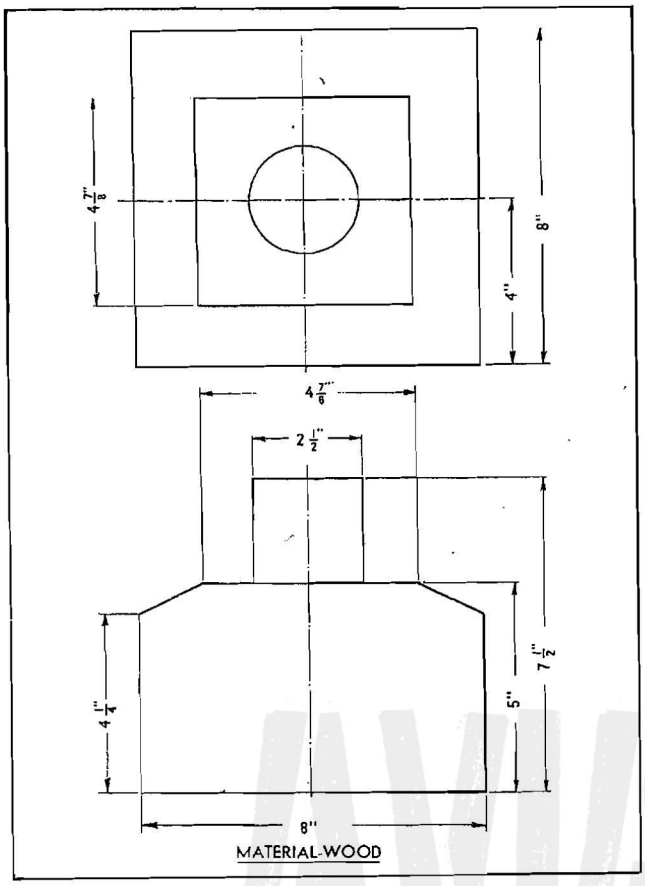

Figure 89—Reduction Gear Disassembly and Assembly Block

provided with a thrust bearing having a split inner race, this will remove only the front half of the inner race. Refer to Figure 90. Lift off the thrust bearing outer race and the retainer and balls after

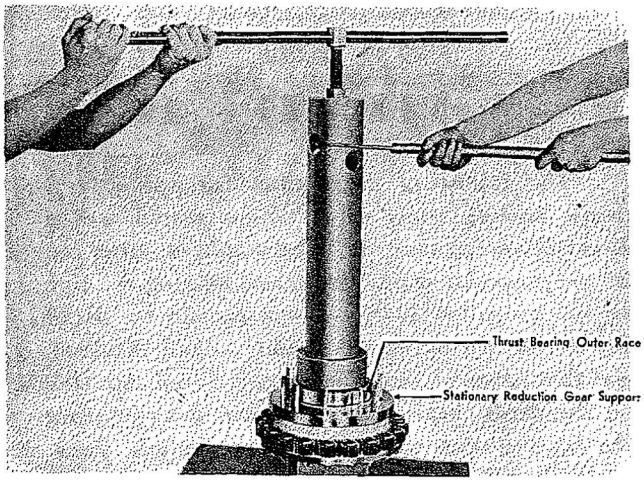

Figure 90—Removing Front Half of Thrust Bearing Inner Race

removal of the inner race front half. Remove the rear half of the inner race using puller (Tool No. 800377) and adapter (Tool No. 801420). Refer to Figure 91. Wrap the outer race, retainer and balls, and the two halves of the inner race together in a

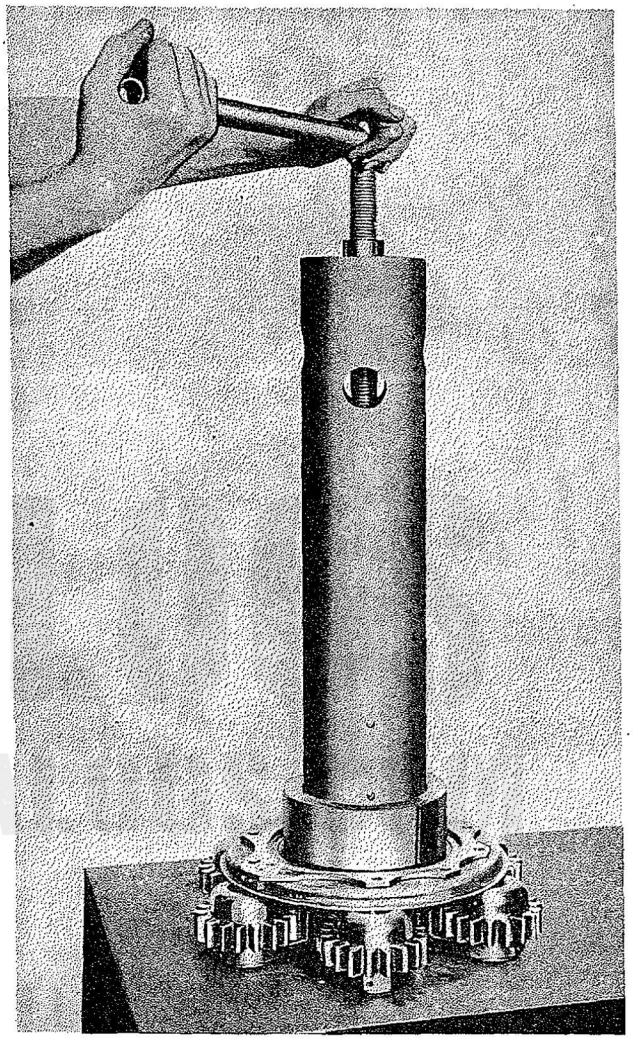

Figure 91—Removing Rear Half of Thrust Bearing Inner Race

cloth or oiled paper. Do not attempt to remove the balls from the retainer.

CAUTION

It is very important that the matched parts of each thrust bearing assembly be kept together. Failure of the thrust bearing during engine operation may result from the use of mis-matched halves of the split inner race, outer race, and retainer and balls.

d. Do not attempt to remove the thrust bearing retainer from the front section. Remove all plugs from the crankcase front section. Remove and discard the T-shaped oil seal ring from the front section rear flange.

42. PROPELLER SHAFT—.666 (3:2) REDUCTION GEAR.

a. In engines provided with a .666 (3:2) reduction gear, proceed with the disassembly of the propeller shaft as follows, after removal of the thrust bearing: Lift the stationary reduction gear and pinion guard ring off the propeller shaft, and remove the eight stationary reduction gear attaching bolts. Remove the thrust bearing spacer and ring assembly, using puller (Tool No. 801362) and jack and pump (Tool No. 801363) if the spacer is too tight on the shaft to permit removal by hand. Slide the collar on the tool over the three legs to hold the tool in place on the spacer. Refer to Figure 92. Remove and discard the rings from the spacer. Care must be exercised to locate correctly the puller in order to avoid removing the dowel pin which locks the propeller shaft rear bushing in .666 (3:2) reduction geared engines.

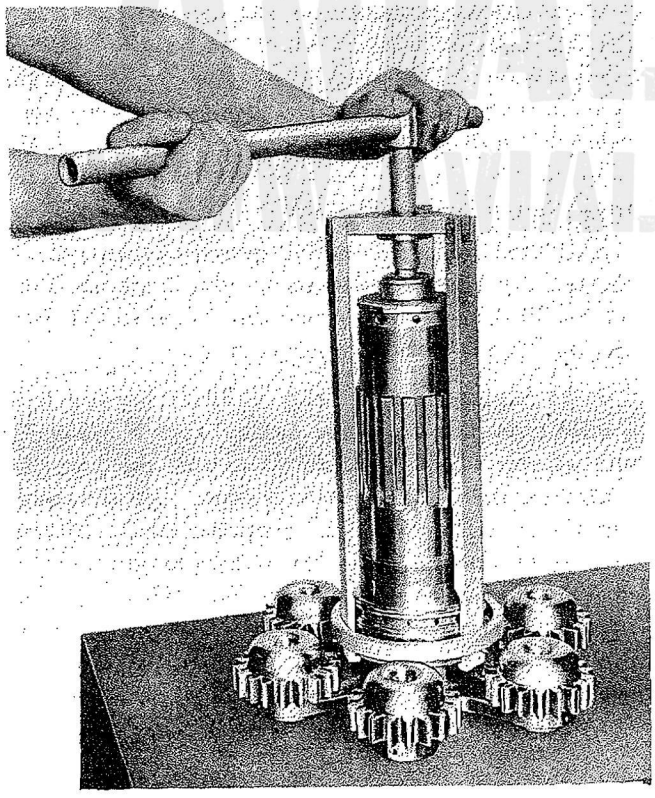

Figure 92—Removing Thrust Bearing Spacer and Ring Assembly

b. Place the propeller shaft in the holding fixture (Tool No. 803592). Remove the cotterpins from the pinion lock bolts. Engage the pinion locking tool (Tool No. 83308) with the teeth of two adjacent pinions, and remove the lock bolts from these pinions using wrench (Tool No. 808562).

NOTE

The pinion lock bolts are provided with a left hand thread. Repeat this operation to remove the remaining lock bolts. Remove the pinions from their trunnions. Remove the propeller shaft from the holding fixture. Refer to Figure 93.

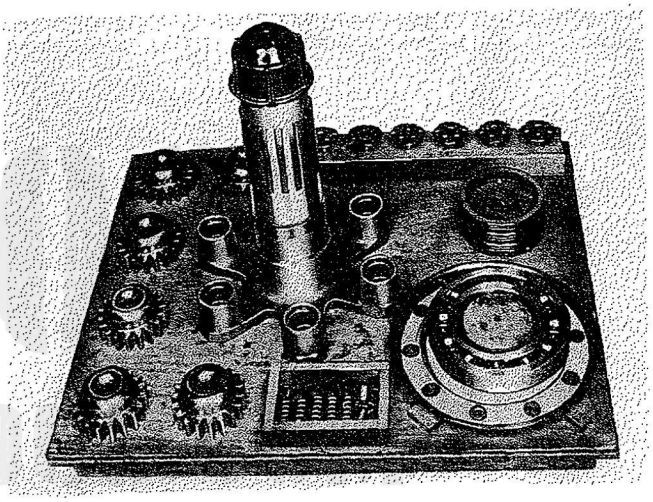

Figure 93—Reduction Gearing Parts Rack 3:2

43. PROPELLER SHAFT—.5625 (16:9) REDUCTION GEAR AND DIRECT DRIVE.

a. In engines provided with a .5625 (16:9) reduction gear, or with a direct drive, proceed with the disassembly of the propeller shaft as follows, after removal of the thrust bearing: Lift the stationary reduction gear support and pinion guard ring or oil seal sleeve support off the propeller shaft.

b. Lift off the stationary reduction gear on reduction geared engines. Remove the thrust bearing spacer and ring assembly, using puller (Tool No. 801-362) if the spacer is too tight on the propeller shaft to permit removal by hand. Refer to Figure 92. Remove the rings from the spacer and discard the rings.

c. Place the propeller shaft of reduction geared engines in the holding fixture (Tool No. 803529). Re-

move the cotter pins from the pinion lock bolt nuts. Using the pinion bolt holding wrench (Tool No. 83507) in the slots in the two bolt heads to prevent the bolts from turning, remove the nuts from these bolts. Refer to Figure 94.

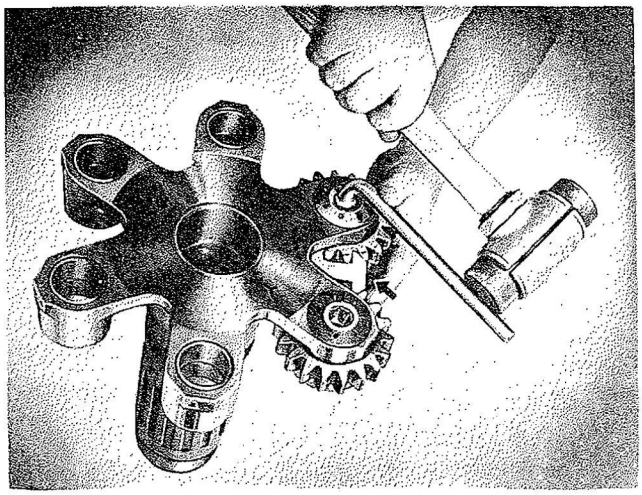

Figure 94—Removing Nuts from Pinion Locking Bolts 3:2

NOTE

The pinion lock bolts are provided with a left hand thread. Repeat this operation to remove the remaining nuts. Remove the pinions and bushings from their trunnions. Disassemble the pinion carrier from the propeller shaft by removing the twenty-four cotter pins, nuts and bolts which secure these parts together. Place part on rack as shown in Figure 95. Remove the propeller shaft from the holding fixture.

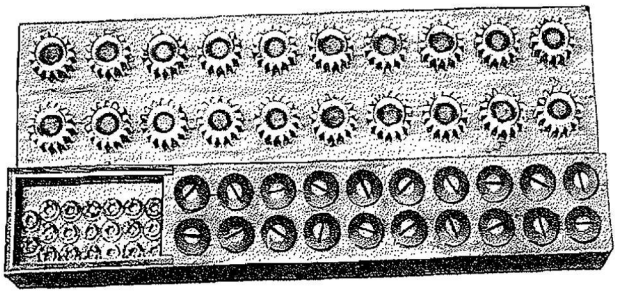

Figure 95—Reduction Gearing Parts Rack 16:9

44. THRUST BEARING, PROPELLER SHAFT AND TORQUE INDICATOR PARTS—.666 (3:2) AND .5625 (16:9) REDUCTION GEARED ENGINES HAVING A TORQUE INDICATOR.

a. For disassembly of the crankcase front section on engines incorporating a torque indicator, proceed as follows: With the crankcase front section on a block remove the lock wire and the 16 bolts and nuts on the torque indicator cell cover, and remove the cover and valve. The ¼—28 threaded hole is provided in the valve for this purpose. Remove the governor drive assembly or the governor substituting cover by removing the four palnuts, nuts, and washers which secure it to the high pressure oil pump. Remove the lock wire and the two screws which fasten the top of the high pressure oil pump to the top of the torque cell housing. This high pressure oil pump, which supplies oil to the torque cell, may now be removed from the crankcase front section by removing the lock wire and four governor attaching nuts, and washers. Remove the lock wire from the cell housing, holding the housing to the case and remove the housing from the crankcase front section.

b. In (.666) 3:2 reduction geared engines, remove the ten nuts and washers which secure the crankcase front section steel flange and aluminum spacer to the front section. The bolts on which these nuts were tightened will not drop inside the front section because they are held in place by circlets. Remove the front section flange and spacer.

c. In .5625 (16:9) reduction geared engines remove the ten cap screws which secure the crankcase front section steel flange and aluminum spacer to the front section. Remove the flange and spacer.

d. In engines incorporating a thrust bearing with a solid type inner race, use puller (Tool No. 800377) and adapter (Tool No. 800378) to free the propeller shaft from the crankcase front section. Lift the crankcase front section from the propeller shaft. During this operation, the stationary reduction gear may or may not remain in the front section. Therefore, care must be exercised to insure that this gear does not fall and injure any parts. If it remains in the front section, place the front section on a bench, front end down, and lift out the stationary reduction gear.

e. In engines incorporating a torque indicator and a thrust bearing with a split inner race, remove the thrust nut, the steel flange and aluminum spacer as above. Replace at least four of the cap screws or

nuts and a sufficient number of washers to pull the torque arm up tight and hold it securely during the following operation. Do not remove the thrust bearing inner race front half. Remove the screen and nut from the propeller shaft as described earlier in this chapter and pack the propeller shaft with dry ice. When the propeller shaft begins to sweat, blow steam into the thrust bearing around the balls. When the propeller shaft has loosened in the thrust bearing inner race, stop the steam and lift the crankcase front section immediately from the propeller shaft.

CAUTION.

As soon as those parts which have been in contact with the steam or dry ice are disassembled, insure that they are thoroughly cleaned with gasoline spray and dried in an air stream. Insure that all traces of water are removed.

f. Because the stationary reduction gear may or may not remain with the pinion gear assembly when lifting the crankcase front section from the propeller shaft, care should be exercised as above to prevent dropping and possibly damaging this part.

g. Remove the remaining nuts and washers or the cap screws and washers, as the case may be, and remove the ten locking circlets from the ten bolts used on crankcase front sections employing a .666 (3:2) reduction gear. For both .5625 (16:9) and .666 (3:2) crankcase front sections with either a solid or split inner race, proceed with the disassembly as follows: Remove the two remaining cap screws in the front section which bolt into the torque arm support and secure it to the front section. Care should be exercised when removing these cap screws, to prevent wedging or locking of the torque arm and support in the crankcase front section. Place the crankcase front section on a bench, front end down, and lift out the torque arm, rollers, and whole assembly. Some manipulation of these parts may be necessary because of the close clearances between these parts and the crankcase front section. After removing the torque arm assembly, lift out the thrust bearing as a unit.

h. Disassemble the torque arm and support assembly by removing the balls which hold the parts together. To do this, place the assembly on a bench with the support down. Hold the support and rotate the torque arm on the balls until the circular slot in the torque arm indexes with the similar slot in the support. Push the balls, one by one, out the circular hole formed by the indexing of these two slots, using a drift between the torque arm splines. The balls are matched with precision with the other details of the assembly, and balls in a particular assembly must be kept together.

45. PROPELLER GOVERNOR DRIVE.

Remove the nuts, or cap screws, and washers which attach the propeller governor substituting cover, if used, to the crankcase front section, and remove the substituting cover. Remove the circlet from the governor drive gear shaft and withdraw the governor drive gear and shaft assembly from the interior of the crankcase front section. Discard the circlet. Disassemble the governor drive gear and shaft by removing the six cap screws which secure these parts together.

46. REDUCTION DRIVING GEAR OR COUPLING.

a. Remove the lock screw from the reduction driving gear or coupling nut. Install the reduction driving gear nut box wrench (Tool No. 82670) over the crankshaft extension and on the nut. To prevent the crankshaft from turning while removing the nut, insert a fiber drift rod 1 3/16 in. in dia. and 8 in. long in the piston pin bushing in the master rod. Turn the crankshaft in an anticlockwise direction, viewed from the front, until the fiber rod rests against the crankcase at the cylinder pad location. Loosen the reduction driving gear or coupling nut by striking heavily on the end of the wrench using a lead hammer. Refer to Figure 96.

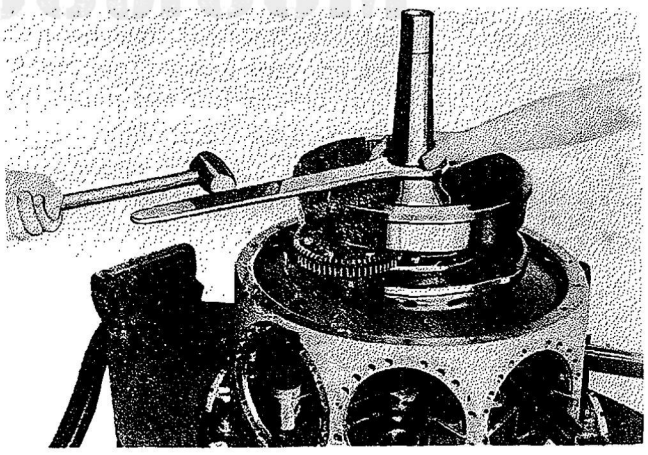

Figure 96—Loosening Reduction Drive Gear Nut

b. Install the reduction driving gear or coupling puller (Tool No. 84857) and three adapters (Tool No. 84858) on the gear. Screw the three adapters into three tapped holes in the gear around the hub. Insert a han-

dle through the hole in the puller screw and remove the reduction driving gear or coupling by turning the handle. Refer to Figure 97. Remove the puller

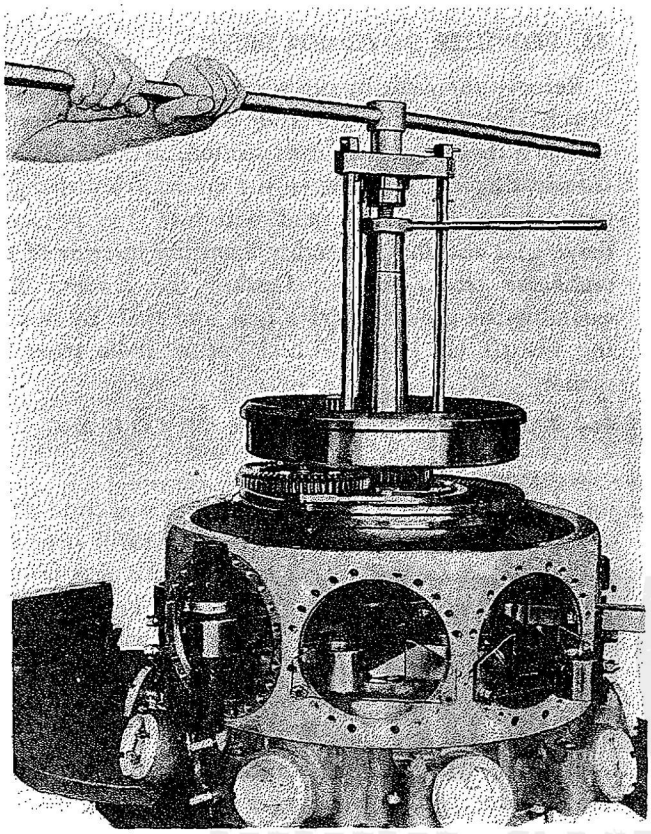

Figure 97—Removing Reduction Gear

and adapters. Remove the fiber rod from the master rod. A hydraulically operated puller (Tool No. 801-208) may also be used with the jack and pump (Tool No. 900026) and adapter (Tool No. 801661).

47. CRANKCASE FRONT MAIN SECTION.

a. Remove the nine cotter pins, nuts, and bolts which attach the two crankcase main sections together. These bolts pass through internal lugs located between the cylinder mounting pads. Use two special box wrenches (Tool No. 84356) to remove these nuts and bolts. Refer to Figure 98. This wrench is provided with a handle curved in such a way that easy access to these nuts and bolts is possible.

b. Lift the crankcase front main section over the crankshaft front extension. Insert three crankcase parting flange protectors (Tool No. 801789) on each side of the crankcase and place the section on a bench,

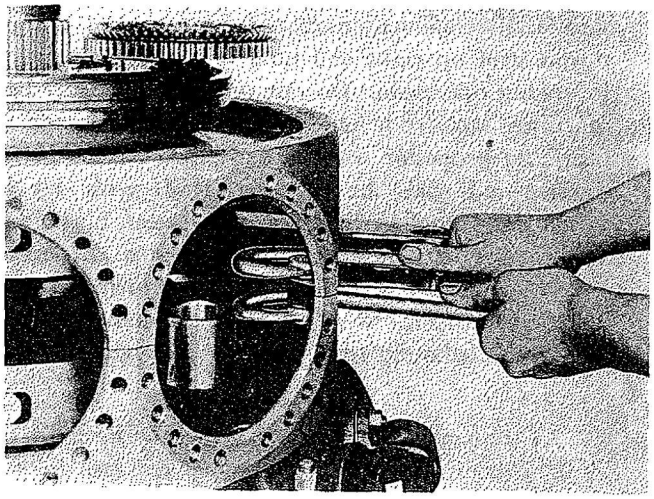

Figure 98—Removing Crankcase Internal Attaching Nuts and Bolts

cam side up. The crankshaft front main roller bearing is of the demountable type. When the front main section is lifted off the crankshaft, the inner race of this bearing remains on the crankshaft and the outer race, retainer, and rollers remain in the bearing ring in the main section.

c. Lift the reduction driving gear spacer, with rings, out of the bore in the front main bearing ring. Remove the rings from the spacer. Discard the rings.

48. CAM AND CAM DRIVE.

a. Break the lock wire from the eight screws which attach the cam drive gear bracket to the crankcase front main section, and remove the screws. Remove the bracket and cam drive gear and pinion assembly. Remove the cam drive gear, bracket spacer and the splined cam bearing ring spacer. Lift off the cam. Do not remove the cam bearing ring unless replacement of this part is found to be necessary. Instructions for replacing the cam bearing ring are included in Section VII, paragraph 26 g.

b. Remove the cotter pin from the cam drive gear and pinion bolt nut. Remove the nut and bolt and the cam drive gear and pinion. Remove the cam drive gear spacer. Disassemble the cam drive gear and the governor drive gear by removing the six cap screws which secure these gears together.

49. CRANKSHAFT FRONT MAIN BEARING.

a. Turn over the crankcase front main section so that the section is resting on the cam bearing ring. Remove the crankshaft front main bearing outer race, retainer, and rollers from the front main section. If

the bearing outer race is tight in the bearing ring, use the crankshaft front main bearing outer race puller (Tool No. 801508). Before using these tools, remove the bearing retainer and rollers from the outer race. To do this, grasp the projecting sides of all the rollers and pull the rollers toward the center of the bearing, after which the retainer and rollers may be lifted out together. Install the puller over the bearing outer race, swing the hooked end of the hinged arms under the lip of the bearing race, and turn the spreader lock to clamp the arms in position. Remove the race.

b. Install the crankshaft front main bearing inner race puller (Tool No. 84562) and the four segments of the split adapter (Tool No. 84564) on the inner race of the front main bearing, locking the tools in place on the race with the collar on the puller. Remove the bearing inner race. Refer to Figure 99.

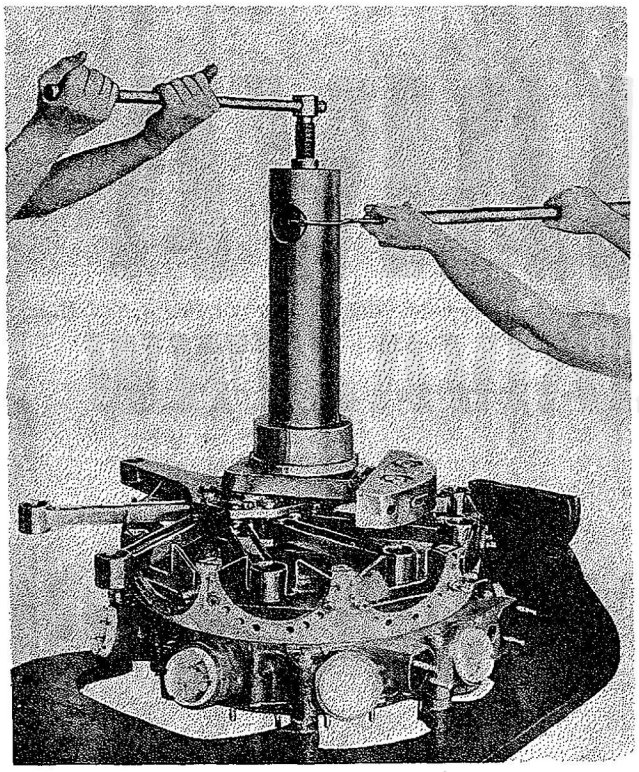

Figure 99—Removing Front Main Bearing Inner Race

Remove the puller and adapter and wrap the front main bearing inner race, outer race, and retainer and rollers together in waxed paper.

50. CRANKSHAFT, MASTER ROD, AND ARTICULATED RODS.

a. Install the crankshaft hoisting eye (Tool No. 82151) over the crankshaft front extension. Tighten the threaded end of the tool on the reduction driving gear nut threads on the crankshaft. Pass the hook on a chain hoist through the hoisting eye and lift the crankshaft and connecting rod assembly out of the

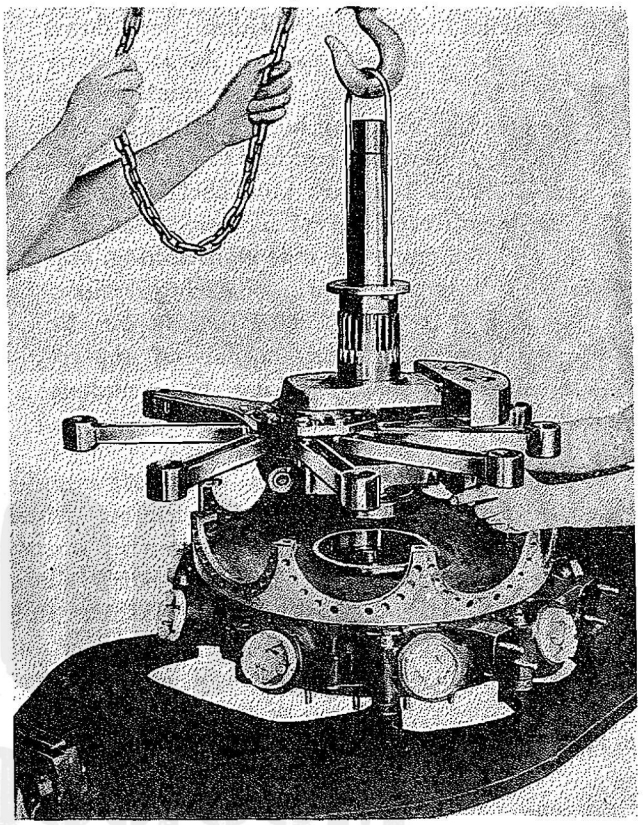

Figure 100—Removing Crankshaft and Articulated Rod Assembly

crankcase rear main section. Refer to Figure 100. The crankshaft rear main bearing remains on the crankshaft, since the diameter of the rear main bearing nut is large enough to prevent the rollers and outer race from being demounted.

CAUTION

If any difficulty is experienced in removing the crankshaft, do not attempt to force the assembly out of the crankcase. In some instances, the rear main bearing outer race is a tight fit in the bearing retainer thus preventing the easy removal of the crankshaft assembly from the crankcase. Any attempt to force the crankshaft free will result in damaging the rollers in the bearing. When this situation occurs proceed as follows: Break

the lock wire and remove the 18 bolts and washers which retain the supercharger front housing and the crankcase rear main section. Carefully raise the crankshaft assembly while supporting the crankcase rear main section. Place the crankshaft assembly in the holding fixture and secure it in position. Bend down the locking tab and remove the lock screw from the rear main bearing retainer nut. Remove the nut using lug wrench (Tool No. 80409). Remove the rear half of the crankcase main section from the crankshaft assembly. Remove the cage and rollers from the outside race in the crankcase rear main section, and tap the outer race from the bearing retainer. Reassemble the rear main bearing on the crankshaft rear section and reinstall the retainer nut prior to checking the crankshaft alignment.

b. It is recommended that the crankshaft assembly be checked for alignment before disassembly. Install the crankshaft and connecting rod assembly on two alignment checking rollers (Tool No. 802694) after removing the hoisting eye from the crankshaft. Hold the master rod in a vertical position and group four articulated rods on both sides of the master rod together, holding each group of rods together with a heavy rubber band. Turn the crankshaft on the rollers and using a dial indicator, check the runout at the front and rear propeller shaft bushing journals on the crankshaft. Refer to Figure 101. The allowable runout at these locations is specified in the Table of Limits in Section XII. This check will indicate whether the crankshaft rear has slipped with relation to the crankpin during past engine operation due to improper clamping.

c. Install the crankshaft in the assembly and disassembly fixture (Tool No. 800710, mounted on floor stand, Tool No. 800711). Tighten the two clamps on the fixture to hold the crankshaft firmly in the fixture, with the counterweights in the downward position. Adjust the knurled head bolt underneath the crankshaft rear counterweight to support the crankshaft during the following operations. Tighten the lock nut on the bolt to lock the bolt in the proper position. Refer to Figure 102.

d. Remove the accessory drive shaft coupling from the recess in the crankshaft rear using puller (Tool No. 801111). Some engines incorporate a coupling lock spring which must be removed before the accessory drive shaft coupling can be removed.

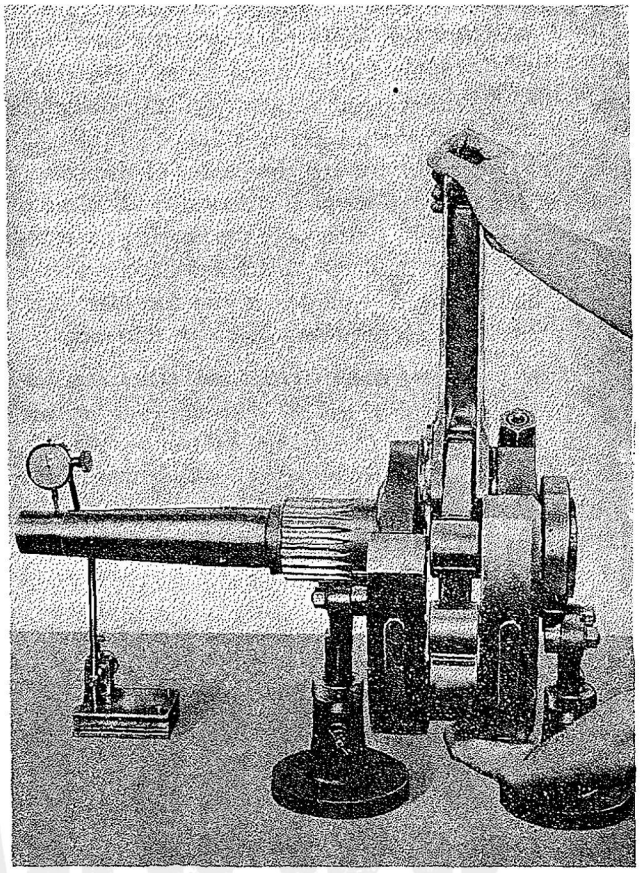

Figure 101—Checking Runout of Front and Rear Propeller Shaft Bushings

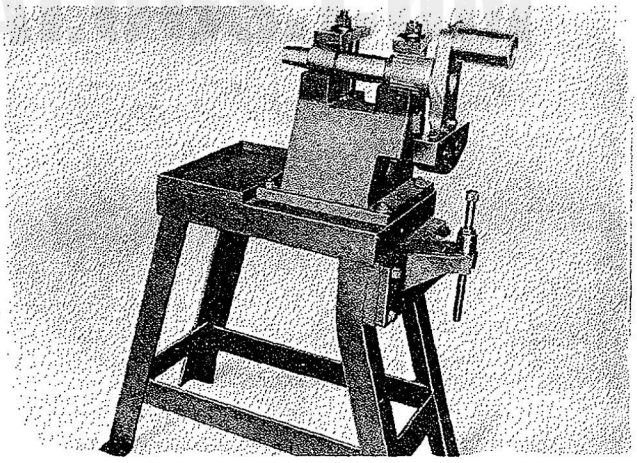

Figure 102—Crankshaft in Assembly Fixture

51. CRANKSHAFT REAR MAIN BEARING.

a. Remove the crankshaft rear main bearing nut lock

screw and locking tab. Remove the nut using lug wrench (Tool No. 80409). Refer to Figure 103. Remove the rear main bearing outer race and rollers from the inner race. Install the crankshaft rear main bearing inner race puller (Tool No. 84559) and the four segments of the adapter (Tool No. 84561) on the bearing inner race, locking the tools in place on the race with the collar on the puller. Remove the race. Refer to Figure 104. Remove the puller and adapter. Wrap the rear main bearing inner race, outer race, and retainer and rollers together in waxed paper.

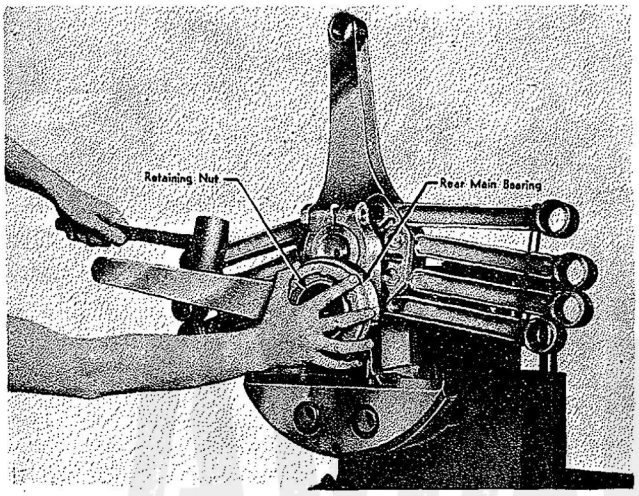

Figure 103—Loosening Crankshaft Rear Main Bearing Nut

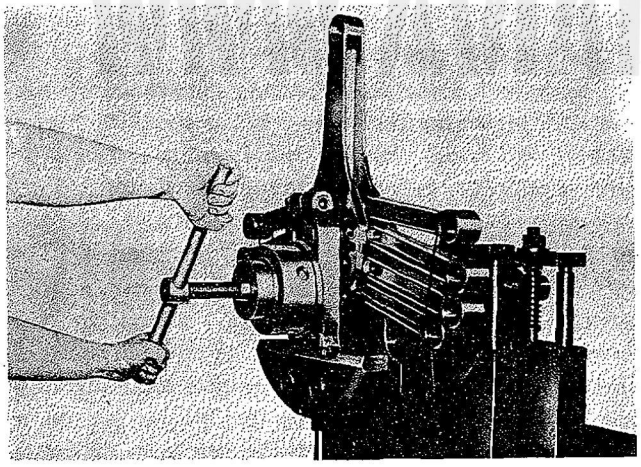

Figure 104—Removing Rear Main Bearing Inner Race

52. CRANKSHAFT REAR END.

a. Remove the cotter pin from the crankshaft rear end cap screw. Loosen the cap screw using wrench (Tool No. 80309) and extension (Tool No. 80198). Refer to Figure 105. Remove the cap screw and

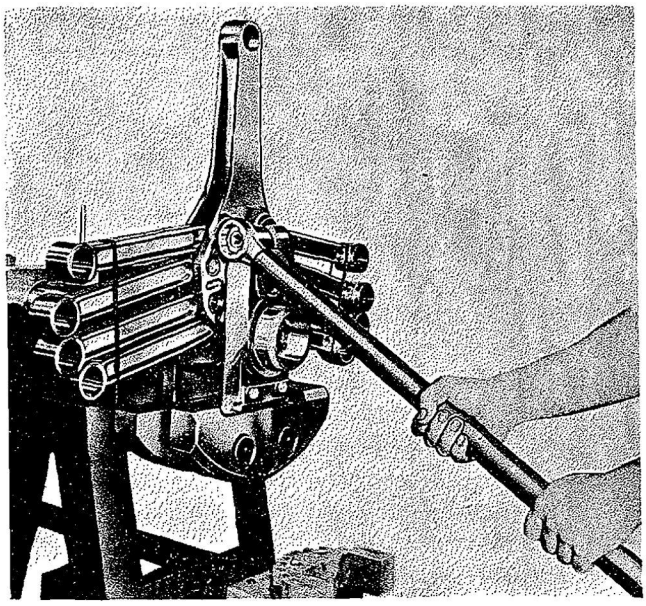

Figure 105—Loosening Crankshaft Cap Screw

washer. Install the crankshaft rear spreader plug (Tool No. 84765-1) in the unthreaded end of the cap screw hole, and install the plate (Tool No. 84765-2) in the slot in the plug so that the plate contacts the side of the clamp joint. Tighten the screw (Tool No. 84699) in the threaded end of the cap screw hole to force the plate against the side of the clamp joint and spread the crankshaft rear. Refer to Figure 106. Do not spread the crankshaft rear any more than is necessary to permit removal of this part. Remove the crankshaft rear from the crankpin, and remove the spreading tools. Place the parts on a rack as shown in Figure 107.

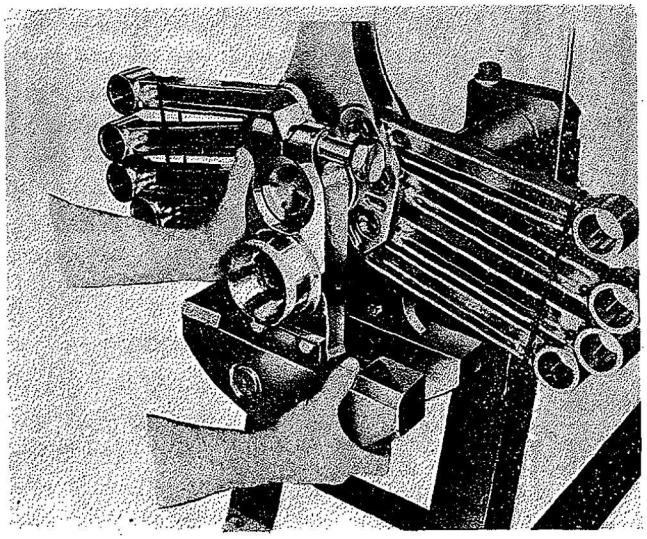

Figure 106—Removing and Installing Crankshaft Rear

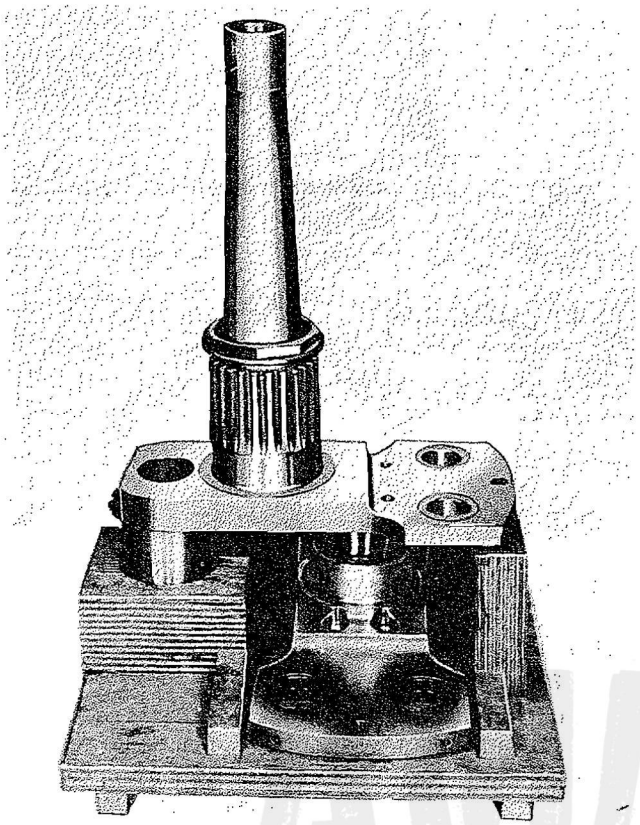

Figure 107—Crankshaft Rack

b. Remove the cotter pins locking the two nuts which secure the crankshaft rear counterweight stop to the crankshaft rear. Remove the nuts, bolts, and the stop. Line up the bushings in the crankshaft rear with the counterweight bushings and remove the counterweight pins. Remove the crankshaft rear from the counterweight. Remove the floating steel bushings from the crankshaft rear. Do not remove the bronze bushings from the crankshaft rear or the steel bushings from the counterweight unless replacement of these parts is necessary. Instructions for replacing these parts are included in section VII, paragraphs 44-46.

53. MASTER ROD AND ARTICULATED RODS.

a. Remove the master rod end seal spacer. Check the rear end of the crankpin to insure that there are no nicks or burrs present which might scratch or score the master rod bearing upon removal of the master rod and articulated rod assembly. Remove any nicks or burrs in this location by stoning and polishing. Grasp the two groups of articulated rods, one on each side of the master rod, and remove the master rod and articulated rod assembly from the crankpin. Refer to Figure 108. Remove the end seal disk and spring.

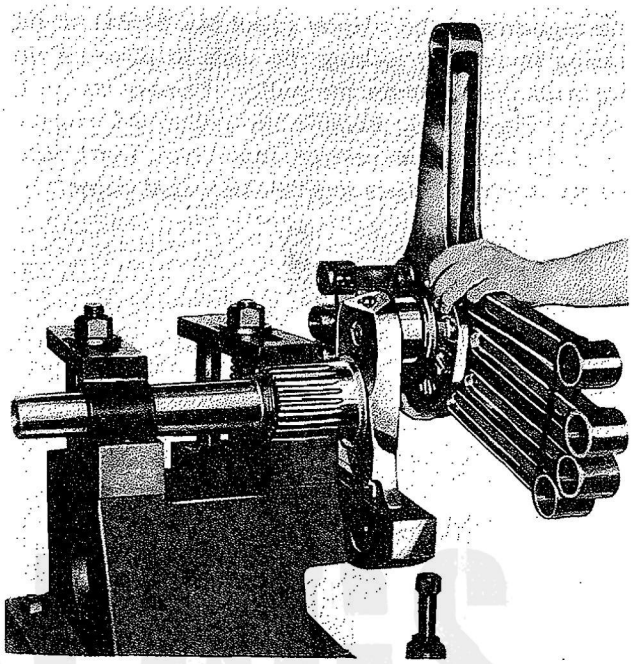

Figure 108—Removing or Installing Master and Articulated Rod Assembly

b. Place the master rod assembly on a bench, rear end down. Remove the knuckle pin lock screws. Lift off knuckle pin locking plate.

c. Remove a loose prefit bearing (identified by the letter "S" preceding the letter "W" at the X-ray serial number) by hand. Handle the bearing carefully to avoid scratching the soft lead-indium plating. Exert a steady pull outward from the master rod. Do not remove the knuckle pins prior to the removal of a prefit bearing. Obstinate bearings may be shrunk with dry ice which has been wrapped in a soft cloth. Do not rotate the bearing while it is being removed. If examination reveals the locating ellipses to be missing, etch, before removing bearing an ellipse (0) on a spline tooth approximately 180 degrees from the bearing serial number. Two spline teeth at the top of the knuckle-pin locking plate should also be etched with ellipses. Time since last overhaul, to the nearest hour, should also be etched or stamped on spline teeth of silver bearing. First number will be etched on the second tooth, to either the left or right side of the ellipse marked tooth on bearing. Leave one tooth blank between notations.

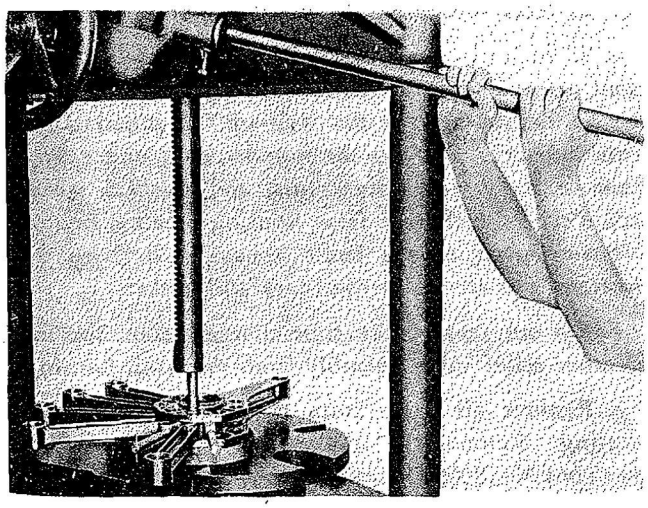

Figure 109—Pressing Out Knuckle Pin

d. Place the knuckle pin assembly and disassembly fixture (Tool No. 83913-1) on an arbor press table. (Tool No. 83913 is a set of tools, and includes all tools necessary for removal and installation of knuckle pins.) Locate the knuckle pin to be removed over a hole in the fixture. Insert the two wedges (Tool No. 83913-19) between the flanges of the master rod, one on each side of the articulated rod to be removed, to prevent possible damage to the master rod flanges when pressing out the knuckle pin. Press out the knuckle pin using the removing plug (Tool No. 83913-20) under the arbor, fitting the step on the plug in the step in the knuckle pin. Refer to Figure 109. Remove the knuckle pin and the articulated rod. Remove all remaining knuckle pins and articulated rods in the same manner, each time moving the wedges to the respective articulated rod. Place the parts on a rack as shown in Figure 110. Do not remove the copper-lead master rod bearing unless replacement of this part is found to be necessary. Do not remove the knuckle pin bushings or the piston pin bushings from the articulated rods unless replacement of these parts is necessary. Instructions for replacing the copper-lead master rod bearing, knuckle pin bushings, and piston pin bushings are included in section VII, paragraphs 47 and 48.

54. CRANKSHAFT FRONT END.

a. Remove the crankshaft breather tube rear support, if used, after bending down the locking tab and removing the lock screw and tab. Remove the crankshaft breather hole plug, which is used in place of the breather tube rear support in engines which employ a supercharger front housing breather, after bending down the locking tab and removing the lock screw and tab. The plug may be removed by inserting a long fiber drift inside the crankshaft front extension and tapping with a fiber mallet.

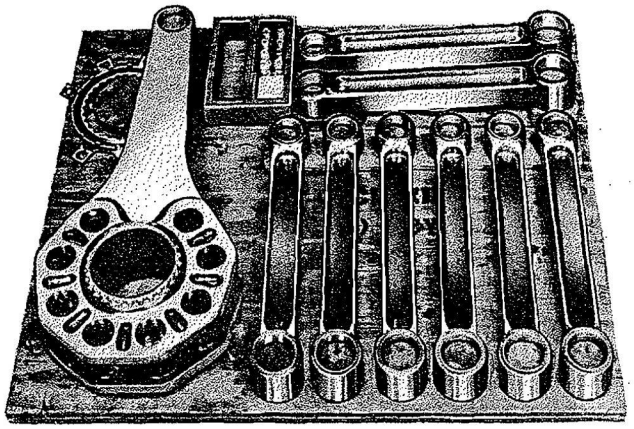

Figure 110—Master and Articulated Rods Rack

b. Remove the crankshaft front end from the holding fixture. Remove the crankpin front plug after bending down the crankpin front plug lock screw tab and removing the lock screw and tab. Use puller (Tool No. 84512 or Tool No. 800477) to remove the plug. (Tool No. 84512 is designed for use with plugs provided with a tapped puller hole. Tool No. 800477 is designed for use with plugs having a slotted puller lip). Refer to Figure 111.

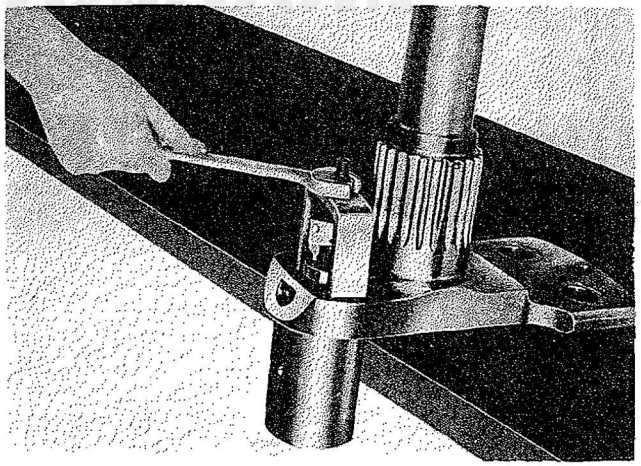

Figure 111—Removing Crankpin Front Plug

c. Remove the crankshaft front counterweight stop, counterweight pins and the counterweight from the crankshaft front end in the same manner as the corresponding parts were removed from the crankshaft

rear. Do not remove the steel bushings from the crankshaft front end or from the counterweight unless replacement of these parts is found to be necessary. Instructions for replacing these parts are included in section VII, paragraph 45.

55. CRANKCASE REAR MAIN SECTION.

a. The following operations should be accomplished with the mounting plate locked in a horizontal position, with the crankcase rear main section up.

b. Remove the lock wire from the eighteen cap screws which secure the crankcase rear main section to the supercharger front housing. Remove the cap screws and washers.

c. Lift the rear main section off the supercharger front housing and install flange protectors (Tool No. 801789) on each parting surface of the main section.

56. SUPERCHARGER FRONT HOUSING BREATHER.

a. If it is necessary to replace the impeller shaft front oil seal support, remove the eight screws which secure the support to the web of the supercharger front housing. Remove the support, ring, and gasket. Remove the two palnuts, nuts, and washers which secure the supercharger front housing breather or substituting cover to the front housing. Remove the breather and screen or the cover and gasket.

b. Do not remove the supercharger front housing breather relief valve assembly from the front housing.

c. Remove all plugs from the supercharger front housing. Remove the intake pipe packing nut covers (Tool No. 800907) from the packing nuts. Remove the packing nuts and packing. Discard the packing.

d. Remove the supercharger front housing from the engine assembly and disassembly stand.

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SECTION V
CLEANING

1. GENERAL.

a. Whenever reference is made to a petroleum solvent, use Federal Specification No. P-S-661.

2. PROCEDURES.

a. Prior to disassembly, remove external oil, dirt, and grease from the engine by pressure spraying with petroleum solvent. After disassembly, pressure spray all parts except the carburetor, magneto, and accessories with petroleum solvent. Flush wash oil tubes, recesses, grooves, and passages that are not accessible for direct cleaning in normal disassembly. Ensure that removable plugs have been removed from parts during disassembly to permit thorough washing of oil and fuel passages. Remove sludge deposits, such as found in crankpins, with a soft, metallic scraper. The carburetor, magneto, and accessories should be cleaned in accordance with manufacturer's instructions.

b. Following the preliminary petroleum solvent wash, clean parts in an approved vapor degreaser. Degreasing, prior to parts immersion into carbon softening solutions, prolongs the effective life of these solutions. Acid condition of trichloroethylene used in vapor degreasers is known to be a definite factor in bringing about corrosion of magnesium parts. It is recommended that all engine overhaul activities set up weekly tests for safe condition of trichloroethylene in use by them. Safe limits and specific titration procedures applicable in each instance must be obtained from the suppliers of this material. Since restoration of acid trichloroethylene to a safe condition by addition of inhibitors is not generally feasible, it is recommended that such material be entirely replaced by a fresh supply.

c. Certain classes of parts, due to adherence of hard carbon and lead deposits, must be cleaned by methods outlined subsequently:

(1) Steel parts, such as gears, shafts, master and articulating rods, cams, crankshafts, supports, pinion carriers, main and thrust bearings less bronze cages, lock plates, knuckle pins, piston pins, valve tappets, rollers, guides and rocker arms are placed in suitable trays or baskets and immersed in carbon softening solutions. When hot type solutions are used, immerse parts approximately two hours. When cold type solutions are used, immerse parts approximately three to four hours. Experience indicates that the hot type carbon softening solutions are more desirable than the cold type where speed of solvent action is a sufficiently critical factor to justify the additional equipment cost. The cold type solutions are used at room temperature. The hot types are used at room temperature. The hot types are used at temperatures up to 60°C (140°F), at which temperature best efficiency is obtained. However, corrosive action of the solutions also increases with temperature increase and, therefore, caution must be used during the cleaning operation to prevent harmful corrosion of the parts due to excessive immersion.

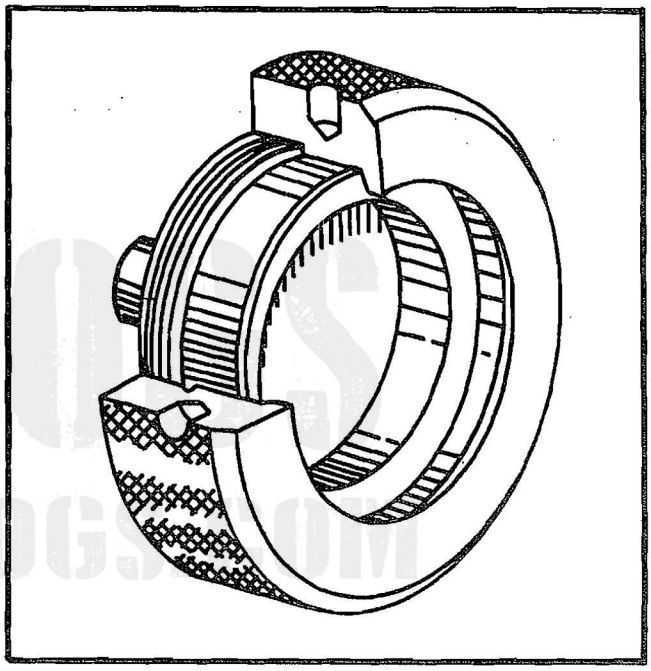

Figure 112—Valve Stem Polishing Holder 804051

(2) Magnesium and aluminum parts ordinarily do not require cleaning in the carbon softening solution, since the parts can be adequately cleaned by petroleum solvent wash and vapor degreasing, and since paint stripping is not recommended as a routine overhaul procedure. If parts require repainting, they may be stripped by immersing parts in hot type solutions for not more than 30 minutes, and in cold type solutions for not more than four hours.

(3) Copper-lead bearings, lead and lead-tin plated bushings and bearings, and silver-plated bushings and bearings should not be cleaned in either the cold or hot

type of carbon softening solutions. Disassemble roller and ball bearings for cleaning. Place the parts, except bronze bearing cages, in a compartmented tray and immerse in carbon softening solutions.

(4) It is occasionally necessary to hand brush parts, using petroleum solvent, to remove softened carbon deposits remaining on parts. After removal of parts from carbon softening solutions, thoroughly rinse in petroleum solvent and dry.

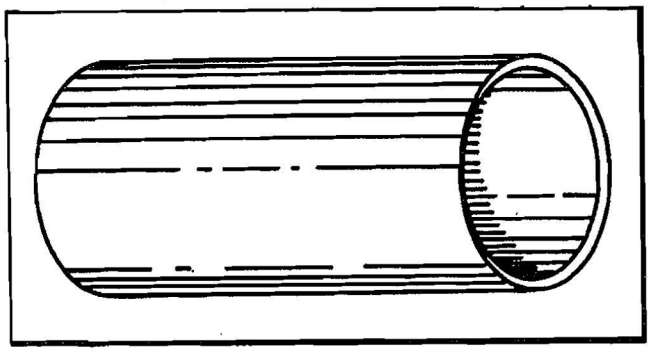

Figure 113—Cylinder Bore Protector

d. Hard grit blast intake and exhaust valve heads, valve springs, and valve washers. Prior to blasting, cover the valve stems with rubber tubing, masking, or friction tape. Insert a rubber plug in the valve washer hole. Remove the stem covering after grit blasting. Chuck intake and exhaust valves in a lathe using holder 804051. See figure 112. Polish stems with 320 grade of abrasive cloth to remove carbon deposits. Use crocus cloth, Specification No. AN-PC-458, wetted with kerosene or petroleum solvent for final polishing. Thoroughly rinse valves, valve washers, and valve springs in petroleum solvent and dry.

e. Soft grit blast interior and exterior surfaces of pistons. Clean oil holes in pistons, if necessary after blasting, with the correct size drill held in a tap handle. Thoroughly wash in petroleum solvent.

f. Soft grit blast interior and exterior cylinder head surfaces. Use a protector in the cylinder bore. See figure 113. Remove carbon and lead deposits accumulating in the annulus between the cylinder head and the end of the cylinder barrel with a motor driven wire brush. Clean the outside of the attaching flange by wire brushing. Chase stainless steel spark plug insert threads with a standard tap. Thoroughly wash cylinders in petroleum solvent and dry.

g. Clean bronze bearing cages in vapor degreaser.

h. Sealing compounds should be removed from the threads of bolts and cap screws by soaking parts in lacquer thinner, Specification No. MIL-T-6094, and hand brushing.

i. Coat all steel parts, after cleaning is accomplished, with corrosive preventive compound, Specification MIL-C-7853.

j. Navy engine parts involved in delay at overhaul should be treated in accordance with General Engine Bulletin No. 27.

k. Before cleaning resin coated parts, Navy personnel should refer to General Engine Bulletin No. 66.

3. CUNO OIL FILTER.

a. Army personnel will refer to the latest revision of Technical Order 03-1-32 for instructions covering the cleaning and servicing of the Cuno filter.

b. Navy personnel will wash the filter in a solvent such as kerosene, unleaded gasoline, or a mixture of carbon tetrachloride and benzol. Cleaning the filter will be facilitated by rotating the cartridge while it is immersed in the solvent. Exercise extreme care to prevent damage to the filter disks and cleaner blades. Immediately after washing, the filter should be immersed in a corrosion preventive mixture composed of one part corrosion preventive compound, Specification No. AN-VV-C-576 and three parts of engine lubricating oil, Specification No. AN-VV-O-446, grade 1120. The filter must not be exposed to a jet of compressed air for cleaning or drying purposes.

4. PRESSURE OIL STRAINER.

a. Soak the oil screen and housing in a pan of clean unleaded fuel. Flush and drain the screen thoroughly before installing it in the engine.

Figures 114, 115, 116 deleted by revision 15 March 1956

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CHAPTER VI
INSPECTION

1. MAGNETIC TYPE INSPECTION.

a. NEED FOR MAGNETIC TYPE OF INSPECTION.—Sub-surface cracks and non-metallic inclusions are impossible to detect by visual inspection alone. Due to the natural permeability of iron and steel, almost all engine parts, fabricated of these materials, lend themselves to what is known as the magnetic type of inspection. By this method of inspection, the aforementioned type of flaws may be located. This section will deal with defects of this nature and their detection by the magnetic type of inspection. The section is designed to present in convenient form, a procedure which the overhaul operator may use safely in inspecting engine parts, and enough information to enable him to understand the procedure.

NOTE

Magnetic inspection of valve springs or other coil springs will not be required by AAF activities.

b. EQUIPMENT FOR MAGNETIZATION AND DEMAGNETIZATION OF ENGINE PARTS.

(1) Special equipment is required to magnetize engine parts which are to be inspected by the magnetic type of inspection. Wherever equipment is available, it is recommended that the operator use this method of inspection on appropriate parts in overhaul work. Patented machines, designed for magnetizing and demagnetizing parts, are on the market in a variety of sizes and models. Tanks, inspection benches, and other accessories are also available. Specific information regarding equipment should be sought from the company by which the equipment is manufactured. Any descriptive references made to equipment in this section are made only in connection with the inspection of engine parts. No attempt will be made to explain the installation, operation, and maintenance of the equipment.

(2) For the average overhaul base the standard Army-Navy unit, equipped with a coil, is recommended as the most practical and the most adaptable all-purpose unit for conditioning parts for the magnetic type of inspection. This unit operates on 110 volt alternating current and delivers direct current from a battery source to the part being inspected. A separate unit is required for the demagnetization of parts in conjunction with the standard Army-Navy unit.

(3) For the small overhaul base, or where economy is essential, an appropriate unit is available, operating on alternating current. No special demagnetizing apparatus is necessary if this unit is employed.

c. PRINCIPLES OF THE MAGNETIC TYPE OF INSPECTION.

(1) The magnetic type of inspection may be described as the interpretation of the effects of the following phenomena:

(a) At sudden interruptions in the path of magnetic fields flowing through a specimen, the direction of the lines of force is deflected, resulting in what are known as "local leakage fields."

(b) If small particles, having satisfactory magnetic properties, are brought into the vicinity of these leakage fields, the particles will be attracted to and held by such fields.

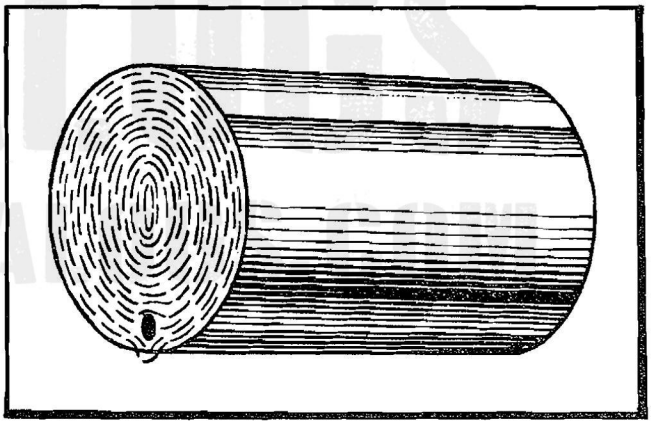

Figure 117—Sketch Showing Sub Surface Defect

(2) Flaws such as non-metallic inclusions or cracks, surface or sub-surface, in a magnetized part will cause local leakage fields. Refer to Figures 117 and 118. Minute particles of iron oxide, when applied to the part, will adhere to such vicinities. By the patterns so formed the inspector can determine the shape and extent of the defect.

(3) The proper use of the magnetic type inspection method and the correct interpretation of the results of its application are of utmost importance. An error in one or the other or both of these operations may result in wasteful scrapping of valuable material or in the ultimate failure of defective parts.

d. MAGNETIZATION OF PARTS.

(1) Magnetic fields may be effected in parts subject to magnetization in one or another of the following ways:

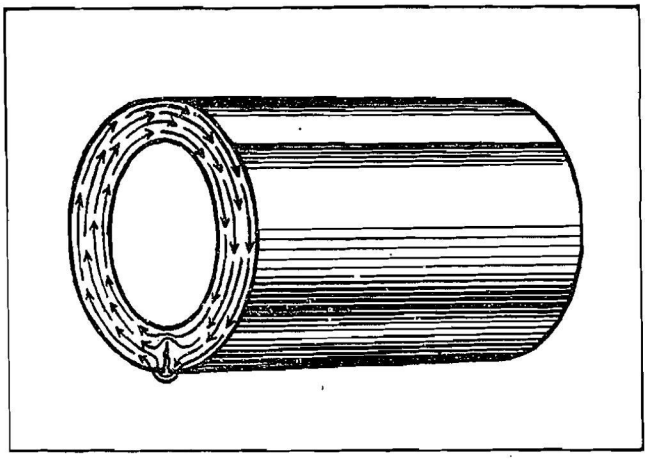

Figure 118—Sketch Showing Surface Crack

(a) The part may be placed directly between two copper contact plates and a current run through the part. Refer to Figure 119.

(b) Parts may be mounted on a copper conductor, the conductor placed between two copper contact plates, and a current run through the conductor. Refer to Figure 120.

(c) A part may be placed in the magnetic field induced by a coiled conductor (usually the coil on the machine). Refer to Figure 121.

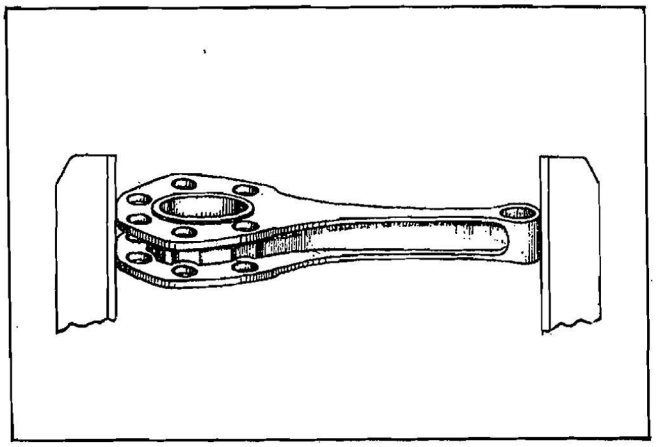

Figure 119—Master Rod Between Copper Contact Plates

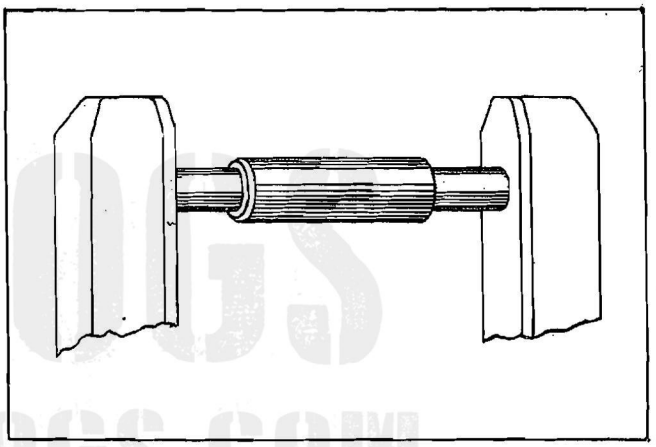

Figure 120—Piston Pin on Copper Conductor Bar

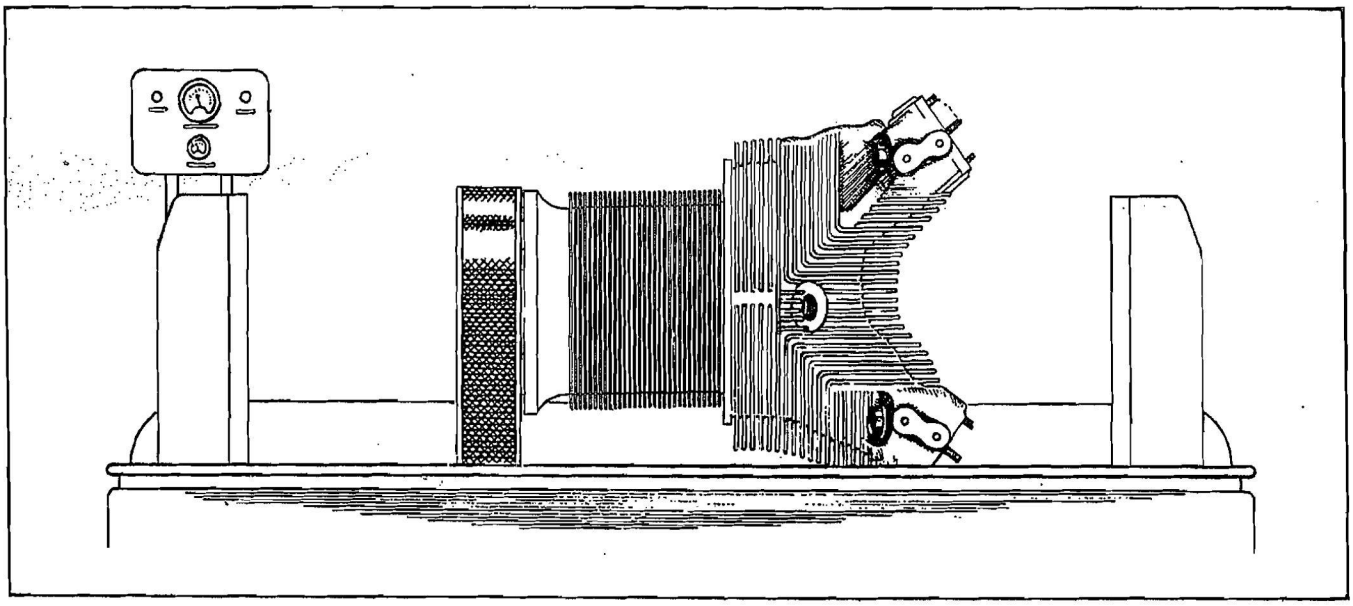

Figure 121—Cylinder Skirt in Coiled Conductor

(2) Different facilities are provided in different units for performing these operations, but the basic processes are the same.

(3) A flaw in a magnetized part is most effectively disclosed by applying iron oxide particles to the part when the magnetic lines of force cross the direction of the defect at right angles. For this reason certain parts must be magnetized in more than one way. The direction in which the magnetic lines of force are to be effected should be governed according to the defects which are suspected to be present, according to the stresses to which the parts are subjected and with a view to defects which may be the result of mishandling of the parts. Refer to the applicable paragraphs under the heading of "Parts Requiring Special Attention" and to the table at the end of this section for the selection of the method of magnetization of parts.

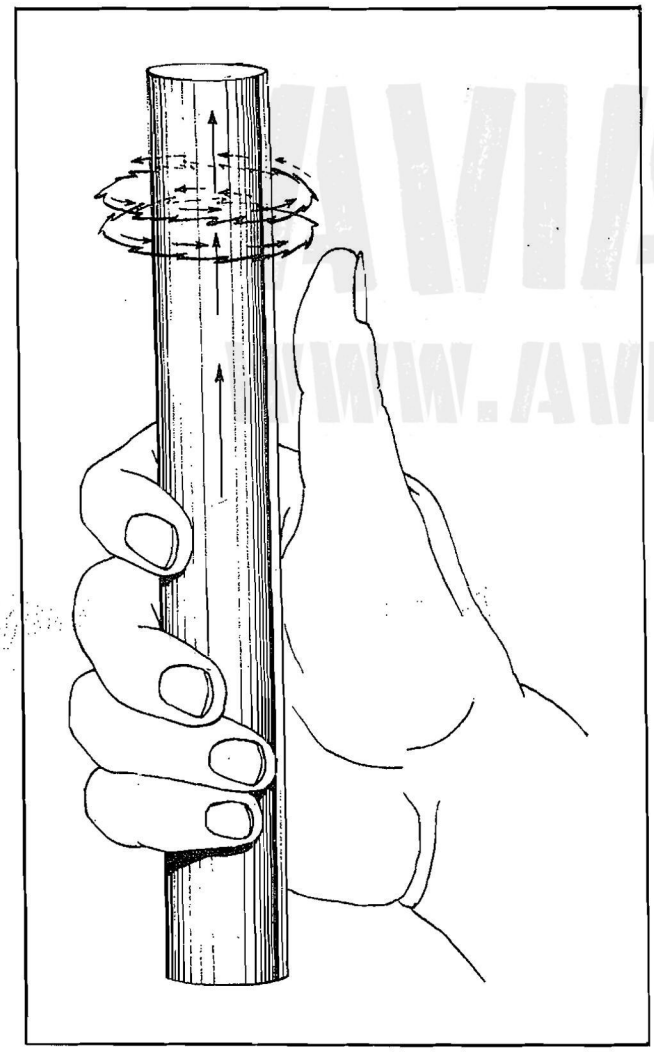

Figure 122—Sketch Showing "Rule of Thumb"

(4) In order to determine how to place a part in the unit to effect a given direction of magnetic lines of force it may be helpful if the operator will remember the popular "rule of thumb." Hold the thumb of the right hand rigidly in the direction in which the current is applied to a part and let the fingers of the hand fall loosely. The direction of the curving fingers will indicate the direction of the magnetic lines of force produced in the part. Refer to Figure 122. This method of magnetization, as produced in *(a)* and *(b)* above, is termed the circular method, the word "circular" designating the direction of the lines of force in the magnetized part.

(5) Referring again to the "rule of the thumb"—if the current is applied in the direction of the fingers, as in *(c)* above, the lines of force will be induced in the part in the direction of the thumb. This method of magnetization, as produced in *(c)* above, is termed the longitudinal method, the word "longitudinal" designating the direction of the lines of forces in the magnetized part.

e. APPLICATION OF IRON OXIDE TO MAGNETIZED PARTS.

(1) Iron oxide particles may be applied to a magnetized part in one of the following ways:

(a) In a dry powdered form (dry method).

(b) Suspended in a solution of varsol or ultrasene (wet method).

(2) The latter, or wet method, has proved to be the more successful of the two, and is therefore recommended whenever feasible.

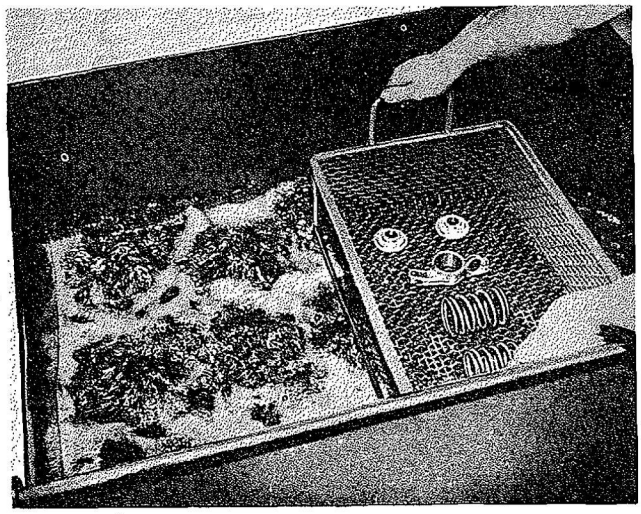

Figure 123—Applying Iron Oxide Particles (Residual Method)

(3) The suspensoid containing the iron oxide particles may be applied to magnetized parts in one of the following ways:

(a) It may be applied as a bath or by hose after the part has been magnetized (residual method). Refer to Figure 123.

(b) It may be applied as a bath or by hose while the part is being magnetized (continuous flow method). Refer to Figure 124.

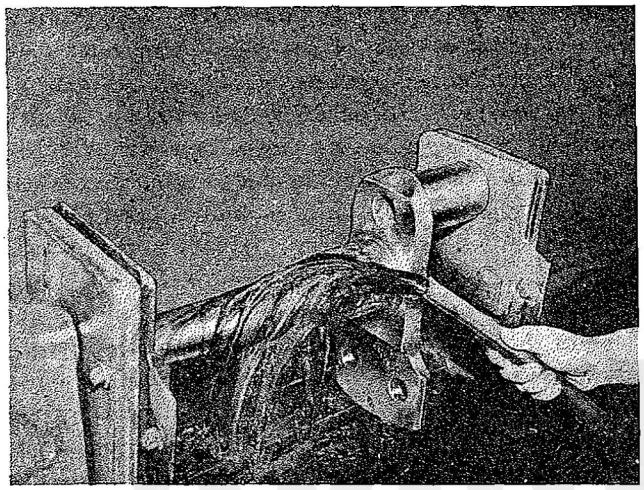

Figure 124—Applying Iron Oxide Particles to Crankshaft with Hose (Continuous Flow Method)

(4) The residual method utilizes only the residual magnetic field existing in the part after the current has been shut off. After the part has been charged the fluid should be applied as in *(a)* above. When applying the continuous flow method, the entire part must be wet with the solution containing the iron oxide particles before and during the application of current. In this continuous flow method, particles will be attracted to local leakage fields at the peak of flux density in the part. The operator must bear in mind that the same amperage, applied to a part, will attract heavier deposits of iron oxide if the continuous flow method is employed than if the residual method is employed.

f. RECOMMENDATIONS FOR THE SUSPENSION.

(1) Various preparations of iron oxide are on the market. Black iron oxide powder is recommended for use in a solution of varsol or ultrasene for detecting defects in magnetized engine parts. In cases where parts are discolored, a red iron oxide powder may be used in place of the black.

(2) It is important to keep the suspension uniform. A proportion of one ounce of iron oxide powder to one gallon of varsol is recommended. The fluid should be constantly agitated to prevent settling of the iron oxide particles. The suspension should not be used for more than eight hours without being tested for uniformity. If a hose is being used, the test sample should be taken from the hose.

(3) To test the suspension, fill a 100 c.c. graduate tube and allow the particles to settle. Place the tube in a demagnetizing unit, disturbing it as little as possible, but holding it close to one wall of the unit. Remove the tube slowly from the unit, and allow it to stand for thirty minutes. If, at the end of this time, the powder at the bottom of the tube reaches the 1½ c.c. mark and does not exceed the 2 c.c. mark, the proportion of iron oxide to liquid is satisfactory. If the test is not within these limits, the proportions should be altered so that the suspension will meet the necessary requirements.

g. INSPECTION OF PARTS.—Parts should be inspected immediately after the application of iron oxide particles. Adequate lighting is essential for proper examination of the parts, and frequently a magnifying glass may be required. All surfaces must be scrutinized for indications of defects. The operator should, however, take into consideration the type of magnetization used before passing judgment on any iron oxide patterns which appear doubtful to him. Refer to the applicable headings *c, d,* and *i* in this paragraph.

h. DEMAGNETIZATION OF PARTS.—Parts should be demagnetized after inspection, or before being remagnetized for checking. To achieve this, place the part in the demagnetizing unit and turn on the current. Rotate the part inside the demagnetizer close to at least one wall of the unit to destroy the field which was induced in the part for its inspection. Refer to Figure 125. Withdraw the part slowly from the demagnetizer, leaving the current on. When the part is approximately 18 in. removed from the demagnetizer, the current may be shut off. To test for demagnetization, hold a compass approximately 6 in. from the part to be tested. If the deflection of the needle does not exceed 3 deg, the part may be considered satisfactorily demagnetized.

i. DOUBTFUL INDICATIONS.—The operator will sometimes find, when using a high amperage in the continuous flow method, that deposits appear in the direction of the grain flow lines of the metal.

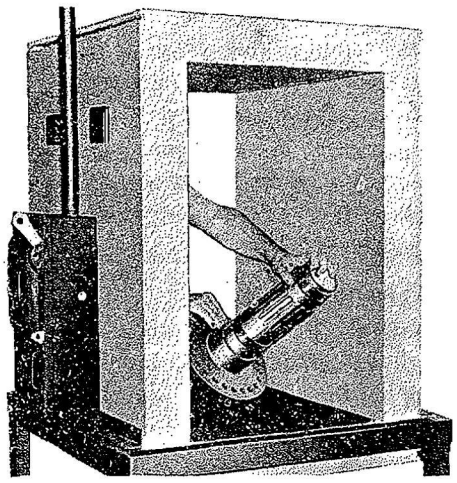

Figure 125—Demagnetizing Part After Magnetic Type Inspection

Other questionable indications may occur, due to other reasons. An irregularly shaped part will attain a saturation point in its thinner sections sooner than in its thicker sections, and will attract heavy deposits in these areas before flaws will be indicated in the thicker areas. Parts which have been permitted to come in contact with a ferrous object during the process of magnetization will also attract deposits in the areas of contact.

j. CHECKING DOUBTFUL INDICATIONS.

(1) Any doubtful indications should be checked. If the continuous flow method was used, mark the area to be checked. Demagnetize the part. Remagnetize and test the part by the residual method. If a dangerous flaw is present, it will reappear, possibly not so heavily marked, but in the same orientation and to the same extent. This will also be true if the part is demagnetized, remagnetized, and tested by the continuous flow method again, reducing the application of current to approximately one-half the amperage originally applied.

(2) If the residual method was used, the part may be wiped and then examined with a magnifying glass. If still no defect is detected, demagnetize the part, remagnetize and recheck it either by the residual method, or by the continuous flow method at one-half the amperage previously used. A serious flaw will reappear in the same manner as described above.

k. DISPOSITION OF PARTS.—Any part found to be seriously defective should be rejected. In most cases, however, experience is the only means of determining the seriousness of flaws which are indicated by the magnetic type of inspection. With certain exceptions, therefore, the standards governing the disposition of parts must be left to the discretion of the Inspection Department. If, after checking by one of the above methods, any indications are found on the end face, on the pitch diameter, or at the root of any gear tooth, this is sufficient cause for rejecting the part. Splined parts should also be rejected in the case of similar indications with the exception of propeller shaft splines where slight indications on the tops of the splines are not dangerous. Indications at corners, steps, or radii of any part which, after magnetic inspection and removal of magnetic powder, can still be seen with the naked eye or with the aid of a small magnifying glass, are cause for rejection of the part. When the operator decides to use a part which has some slight indication, it is well to keep a record of that indication for future reference at the next overhaul. This may be done by applying a piece of transparent scotch tape to the part to pick up the pattern of the indication, removing the tape and pasting it on a suitable card. This operation transfers the pattern from the specimen to the paper. In this way the progress of the flaw may be observed at a subsequent inspection. Parts rejected as a result of this inspection will be properly prepared for storage, tagged and set aside. AAF personnel will submit an Unsatisfactory Report, if not previously accomplished, to Headquarters, A.S.C. in the regular manner. Navy personnel will submit report to Aviation Supply Office, Philadelphia, Penn. If an Unsatisfactory Report was submitted on the engine prior to disassembly and inspection, disclosure of the defective part will be listed in the disassembly and inspection report. (Parts reported as above will not be handled as junk pending disposition instruction.) Also mention should be made as to whether the parts are considered repairable locally or by the manufacturer.

l. PRECAUTIONS.

(1) All parts being magnetized for inspection must first be thoroughly cleaned.

(2) All parts should be completely disassembled before magnetization with the exception of those specifically mentioned under hearing *m.* of this paragraph, and in the table at the end of this section.

(3) Any passages which might trap the solution should be blocked with vaseline. Passages thus blocked should be freed and checked for clearness after the part has passed inspection and has been demagnetized.

(4) In order to avoid the possibility of arcing when applying current, the operator should be careful to see that the contacts are clean and tight. Lead plates covering the contact plates are effective for keeping the parts from being injured, but the lead must not be allowed to become too mutilated or faulty contacts will result and this may lead to arcing or burning. The part should be held in position until the ammeter registers zero.

(5) All parts must be demagnetized after inspection.

(6) All parts must be cleaned and suitably slushed after demagnetization.

(7) Do not magnetize antifriction bearings unless specifically directed. It is too difficult to remove all the iron oxide particles from these bearings and any residual particles would have a damaging abrasive effect if the part should be put into operation. As antifriction bearings have a tendency to become magnetized in operation, it is recommended that these parts be demagnetized before reinstallation. After demagnetizing a bearing, clean it carefully according to instructions and wrap it in waxed paper until time for use. For further information on bearings, refer to Section VII, paragraph 4.

(8) When parts are mounted on a conductor they should not touch the contact plates or each other. Parts should be sufficiently separated to permit the solution to come in contact with all surfaces. No ferrous material should touch a part during the process of magnetic inspection.

m. PARTS REQUIRING SPECIAL ATTENTION.

(1) The following parts should receive special attention, using the continuous flow method. When the use of copper tubes or rods is recommended, their outside diameters should fit as nearly as practicable the inside diameters of the parts with which they are used.

(a) ARTICULATED RODS.—Magnetize these parts in three directions.

1. Pass the current directly through the part from end to end at 1500 amperes.

2. Place a copper rod through the knuckle pin end of the rod and pass 1500 amperes through the copper rod. (Copper rod to be 15 in. long). Five articulated rods may be magnetized at one time.

3. Place a copper rod through the piston pin end of the rod, using the same procedure as in "2" above.

(b) MASTER RODS.—Magnetize these parts in three directions.

1. Pass the current directly through the part from end to end, using 2500 to 3000 amperes. Refer to Figure 126.

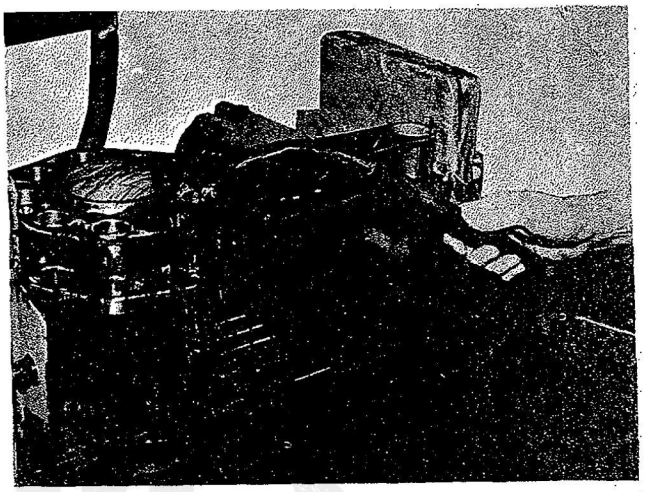

Figure 126—Passing Current Through Master Rod End to End

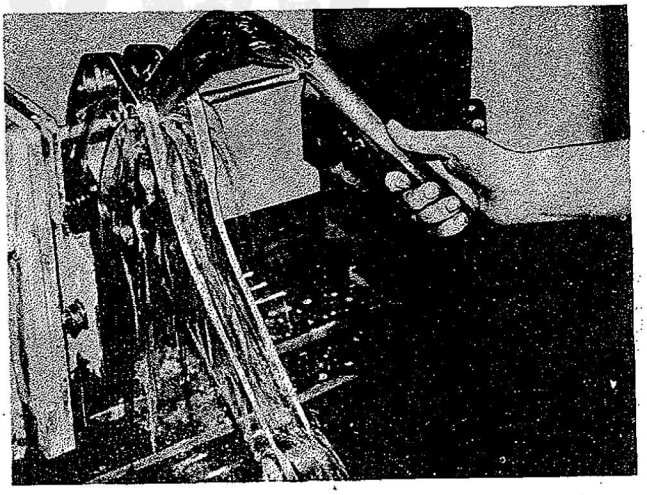

Figure 127—Copper Tube Through Master Rod Crankpin Bore

2. Place a copper tube through the crankpin bore and pass 2500 to 3000 amperes through the tube. Refer to Figure 127.

3. Place a copper tube through the piston pin bore and pass 2500 to 3000 amperes through the tube. Refer to Figure 128.

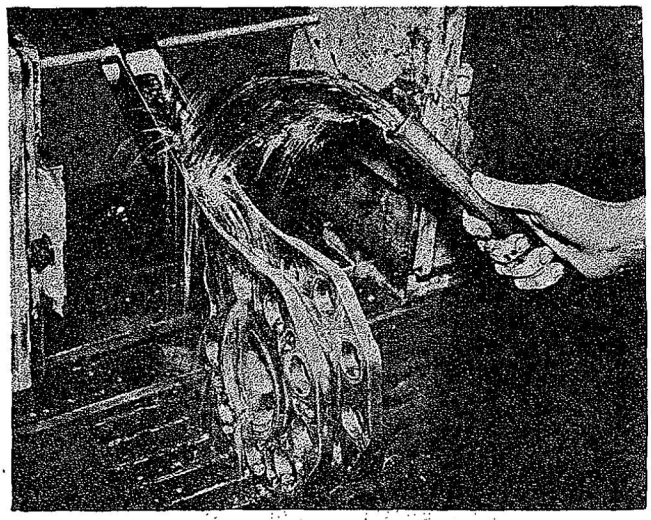

Figure 128—Copper Tube Through Master Rod Piston Pin Bore

(c) CRANKSHAFT FRONT AND REAR SECTIONS.—Magnetize these sections in one direction through each individual section from end to end with the grain flow of the metal at 2500 to 3000 amperes.

(d) PROPELLER SHAFTS.—Magnetize propeller shafts in a similar manner to that used for crankshafts, using 2500 to 3000 amperes. Refer to Figure 129.

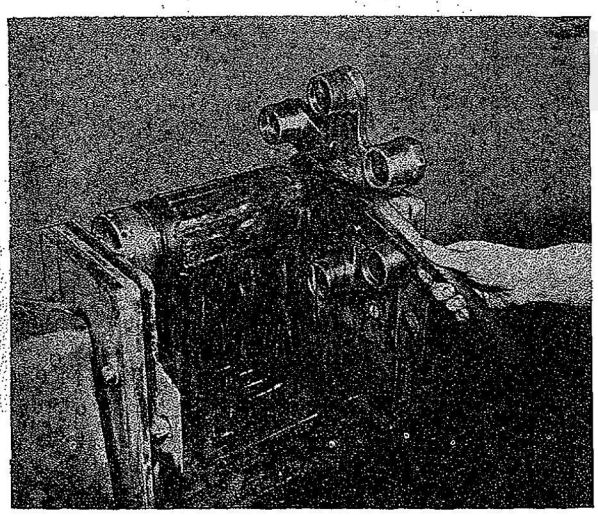

Figure 129—Magnetizing Propeller Shaft—End to End

(e) CRANKCASE FRONT AND REAR MAIN SECTIONS.—Magnetize crankcase by placing a copper tube through the center of the case and by passing 2500 to 3000 amperes through the copper tube. Since it is usually impracticable to use a copper bar large enough to fit the inside diameter of the crankcase sections, it is advisable to repeat the process of inspection three times, turning the crankcase 90 degrees on the bar each time. If a tank is available, it is more expedient to submerge the crankcase section in the bath and pass the current through it.

Par. 1. m. (1) *(f)* deleted in revision dated 5 March 1945.

(g) VALVES AND VALVE SPRINGS.—Magnetize these parts in one direction by passing the current directly through the part. Exhaust valves are not

Figure 130 deleted in revision dated 5 March 1945.

Figure 131 deleted in revision dated 5 March 1945.

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Figure 132 deleted in revision dated 5 March 1945.

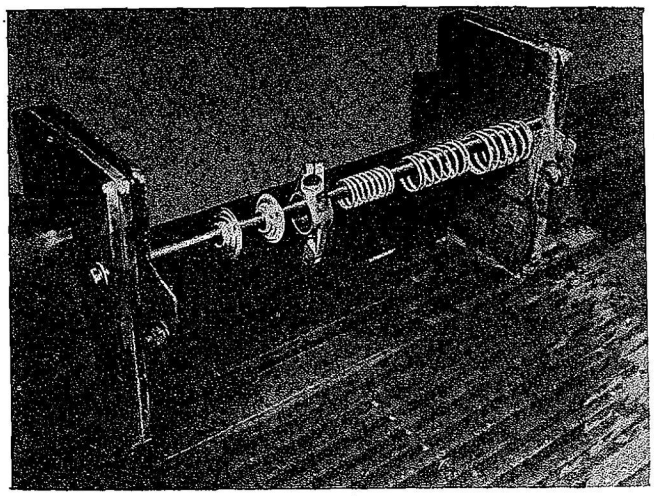

Figure 134—Magnetizing Rocker Arms, Valve Washers, and Valve Springs

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Figure 133 deleted in revision dated 5 March 1945.

inspected by the magnetic method except when tip defects are suspected. For intake valves use 800 to 1000 amperes; for valve springs, use 300 amperes.

(b) ROCKER ARMS.—Magnetize these parts in one direction by passing a current directly through the parts, using 1000 amperes. Refer to Figure 134.

n. TABLE.—The following table has been prepared for use in conjunction with the preceding paragraphs in order to enable the operator to eliminate error in the procedure for inspecting specific engine parts. Any parts not listed, which are appropriate parts for the magnetic type inspection, should be classified by the operator according to the general instructions given herein. When the table specifies that a part should be magnetized in two ways, refer to the note at the end of the table.

Part	*Method*	*Amperage*
Accessory Drive Gear and Coupling	Residual—two ways	2000
Accessory Drive and Starter Shaft	Residual	2000
Articulated Rod	See paragraph *m. (a)*	
Ball Socket	Residual	800–1000
Crankcase	See paragraph *m. (e)*	
Crankshaft Cap Screw	Residual	1500
Counterweight Pin	Residual	1500
Counterweight Bolt	Residual	1000
Cam	Residual—across outside diameter	2000
Cam Drive Gear	Residual—two ways	1500
Oil Pump Drive Gear	Residual—two ways	2000
Deleted in revision dated 5 March 1945.		
Impeller Pinion	Residual	1000
Impeller Drive Carrier Support	Residual	2000
Impeller Shaft	Residual—two ways	1500
Impeller Shaft Oil Seal Sleeve	Residual	1500
Governor Drive Gear	Residual—two ways	1500
Master Rod	See paragraph *m. (b)*	
Knuckle Pin	Residual—two ways	1500
Master Rod End Seal, Disk, and Spacer	Residual	1000
Master Rod Knuckle Pin Lock Plate	Residual	1000
Piston Pin	Residual	1500
Oil Pump Gear	Residual—two ways	800
Fuel Pump Drive Shaft	Residual	1000
Reduction Drive Gear Retaining Nut	Residual	1500
Reduction Drive Gear	Residual—two ways	2500
Rocker Arm	See paragraph *m. (b)*	
Rocker Arm Adjusting Screw	Residual	500
Rocker Arm Hub Bolt	Residual	500
Reduction Gear Pinion Carrier	Residual	2500
Reduction Gear Pinion	Residual—two ways	2000
Propeller Shaft	See paragraph *m. (d)*	
Accessory Drive and Starter Shaft Coupling	Residual	1500
Push Rod	Residual—end to end	500–800
Starter Coupling	Residual—two ways	2000
Supercharger Oil Seal	Residual	1500
Fuel Pump Drive Shaft Bevel Gear	Residual—two ways	750
Valve, Intake	See paragraph *m. (g)*	
Valve Spring (Navy only)	See paragraph *m. (g)*	
Valve Tappet and Roller	Residual	1000

NOTE

All gears and shafts with gears should be magnetized by both the circular method, paragraph *d. (a)* or *(b)*; and the longitudinal method, paragraph *d. (c)*.

All plain shafts, rings, nuts, and spacers should be magnetized by the circular method, paragraph *d. (a)* or *(b)*. Refer to figures 135, 136, 137, 138, 139, 140, and 141 for magnetizing parts.

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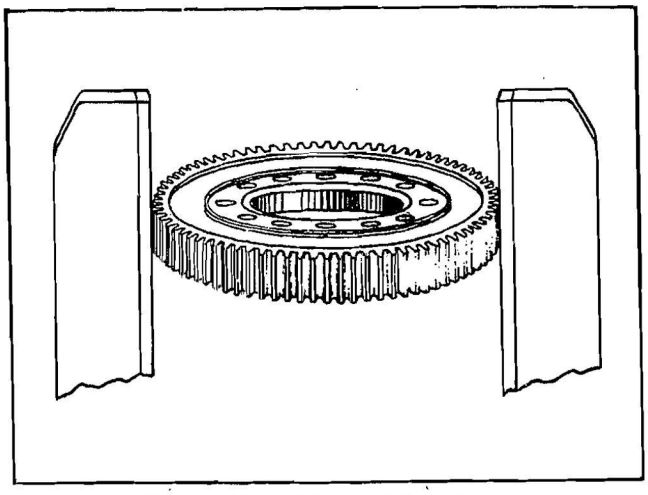

Figure 135—Magnetizing Gear

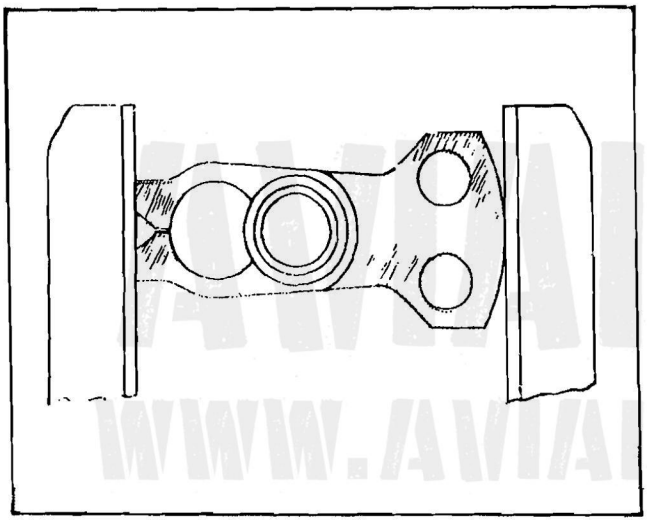

Figure 136—Magnetizing Crankcheek

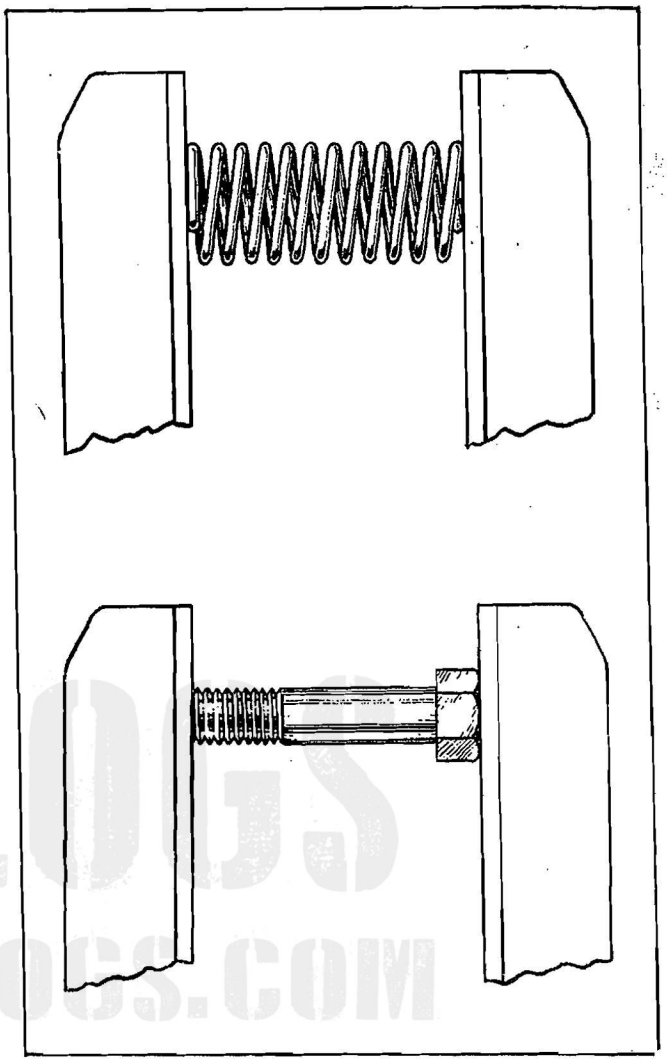

Figure 137—Magnetizing Small Parts

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2. ANTIFRICTION BEARINGS.

a. Do not inspect antifriction bearings by the magnetic type method. The inspection of an antifriction bearing is best performed after the bearing has been washed, dried and dipped in light oil.

b. The condition of antifriction bearings is principally determined by the surface condition of the balls or rollers and races, the axial looseness and the radial looseness.

c. The condition of the surfaces can be determined by a visual inspection, using a magnifying glass if necessary. Spinning the bearing while holding it in the hands is not an accurate check of its running qualities, although this test will indicate the presence of dirt or foreign matter in the bearing as evidenced by

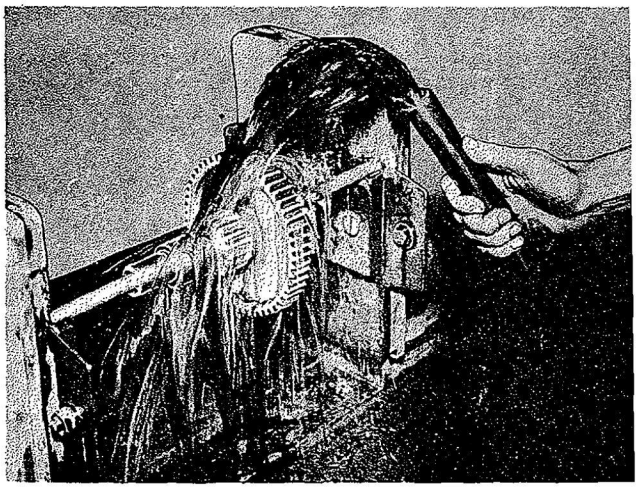

Figure 138—Magnetizing Impeller Drive and Pinion Gear on Bar

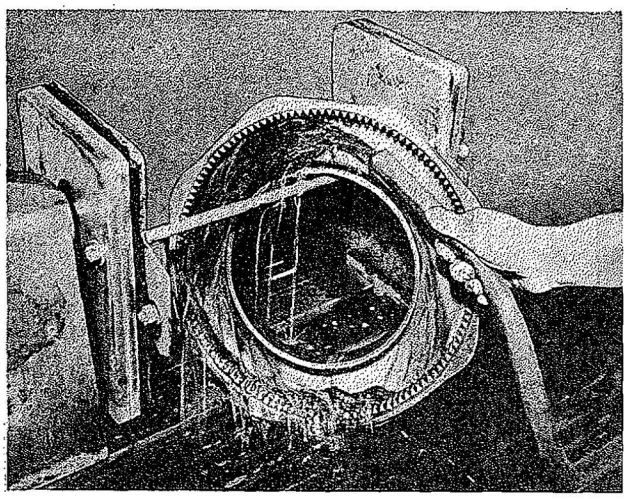

Figure 139—Magnetizing Cam on Bar

Figure 140—Magnetizing Impeller Drive and Pinion Gear in Coil

the bearing sticking in places or turning jerkily. A bearing in this condition should be rewashed, lubricated and again checked. The sticking of a ball bearing should not be considered as being caused by a flat spot on one of the balls as it is extremely unlikely that such a condition could exist without complete failure of the bearing. A careful check should be made of the surfaces to detect wear or a pitted condition caused by corrosion. Check for overheating, evidenced by discoloration of the balls, races or retainers. Such a condition must not be confused with discoloration caused by the lubricant. This type of discoloration is merely a thin deposit on the surfaces, is not harmful and therefore need not be removed. *Do not etch* any part of a bearing when inspecting for cracks.

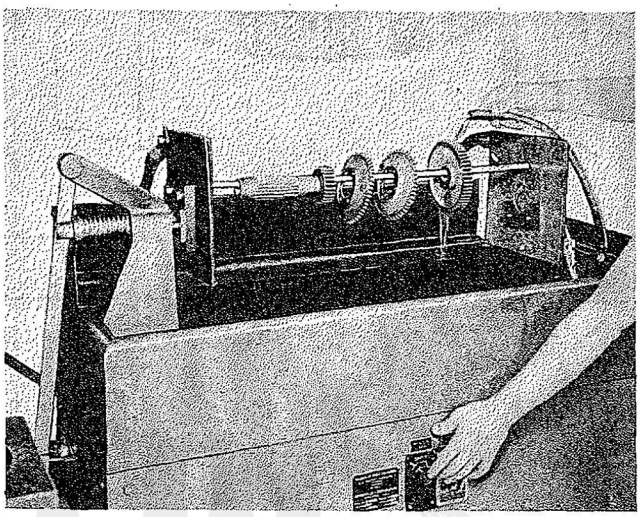

Figure 141—Magnetizing Tubular and Ring Shaped Parts

d. It is not necessary to make a check of the radial looseness of a ball bearing, since determination of the axial looseness provides sufficient information to judge the amount of bearing wear. There is a relationship between these two clearances in a ball bearing so that by knowing one the other can be calculated if desired. The most satisfactory method of determining the axial looseness is to clamp the inner race of the bearing securely on a surface plate. Two plugs or flat plates must be used, one under and one over the inner race, the lower one raising the bearing off the surface plate. With a dial indicator located so that its spindle contacts the upper side of the outer race, oscillate the outer race and at the same time press it downward until the maximum reading is obtained.

Reverse the action, this time pulling the outer race upward while oscillating it, and note the difference between the former reading on the indicator and the present one. The difference represents the amount of axial looseness. Refer to the Table of Limits for the maximum permissible axial looseness for each bearing.

e. The condition of the outer surfaces of the bearing races must be considered when deciding whether or

not a bearing is fit for further use. If these surfaces are galled or scored the inspector must decide whether they can be reconditioned by stoning. Ball or roller retainers must be checked for cracks and wear.

f. Except for stoning the outer surfaces of a bearing to remove scoring or galling, no repairs should ever be attempted on a bearing. Never disassemble a non-demountable type bearing if it is to be used again.

g. As soon as a bearing has been inspected, wash it and dip it in clean kerosene, and then pack it with corrosion preventive mixture.

h. After cleaning and before packing with corrosion preventive mixture, the bearing should be thoroughly demagnetized. This applies to all antifriction bearings in the engine, and in the case of demountable type roller bearings the inner race, spacer, and washer as well as the rollers and outer race should be demagnetized. This operation can be readily accomplished by passing the part through the demagnetizing coil of the magnetic type inspection equipment.

CAUTION

Do not attempt magnetic type inspection on antifriction bearings. Bearings in normal operation tend to pick up a certain amount of magnetism which would hold small metal particles and increase wear. It is for this reason only that all bearings must be demagnetized.

i. As soon as this is done, wrap the bearing in oiled paper and do not uncover it until the time it is to be assembled in the engine.

3. CRANKCASE FRONT SECTION.

a. GENERAL.

(1) Inspect the crankcase front section for cracks. Any part of the front section about which the inspector is doubtful as to the presence of a crack should be inspected with a magnifying glass, and if necessary, etched. Extreme care should be exercised in the use of etching fluid. Use particular care in inspecting the front section in the location of bolt holes and studs, the thrust bearing location, and at the parting flange. *Under no circumstances should a case be used if it is cracked.* Inspect the finished surfaces for scratches or nicks and for high spots around the studs.

(2) Inspect all studs for straightness, tightness, stretching, and condition of the threads. Order replacement of all studs that are bent, loose, stretched, or that show evidence of pulling.

(3) Inspect all oil passages in the front section for cleanliness and freedom from obstruction.

(4) Inspect the flange and the inside diameter of the thrust bearing retainer for galling or roughness, and for tightness in the front section. Inspect the inside diameter of the thrust bearing retainer and the outside diameter of the thrust bearing outer race, using micrometers, to determine the fit. Refer to the Table of Limits in Section XII. If replacement of the thrust bearing retainer is found to be necessary, the crankcase front section will be properly prepared for storage, tagged and set aside. AAF activities will submit an Unsatisfactory Report to the Headquarters, Air Service Command, and Naval activities will contact the Aviation Supply Office, Philadelphia, Penn., for disposition instruction.

(5) Inspect the governor drive gear shaft bushing for scratches, burrs, and wear. Inspect the fit of the governor drive gear shaft in the bushing. Refer to the Table of Limits in Section XII.

(6) Inspect the cap screws which attach the front section to the crankcase front main section for burrs, cracks, straightness, and condition of the threads and hexagonal head.

(7) Inspect the aluminum front section spacer for cracks, smoothness of the contacting surfaces, and condition of the bolt or stud holes. Inspect the steel front section flange for cracks, and the inside diameter of the flange for roughness or wear caused by the thrust nut oil seal ring.

b. PROPELLER GOVERNOR DRIVE.

(1) Inspect the governor drive gear for cracks and for chipped, cracked or broken teeth. Inspect the screw holes in the gear for mutilation of the threads. Inspect the governor drive gear shaft for nicks, burrs, and condition of the bearing surfaces. Inspect the screws which attach the gear to the shaft for condition of the threads and the hexagonal head. Inspect the governor substituting cover for cracks and condition of the finished surfaces.

c. VALVE TAPPETS.

(1) Inspect the outside diameter of all valve tappets for cracks and scores. It is important that these surfaces have a high finish as a precaution against seizure of the tappet in its guide. Check the tappets for the correct dimension on the outside diameter. Tappets with diameters of less than .81125 in. should be replaced. Recheck the tappet diameter in a location 90 deg from the first checking point to indicate an out of round condition. Order replacement of all

tappets which are scored, are not of the correct diameter, or are out of round on the outside diameter. Inspect the tappets for cleanliness of the oil holes and the inside diameter.

(2) Inspect the valve tappet ball sockets for cracks, scores, cleanliness of the oil hole, and wear of the spherical socket. Check the fit of the ball socket in the tappet. Refer to the Table of Limits in Section XII. Check the ball socket springs for proper tension. Refer to the Table of Limits in Section XII. Inspect the tappet rollers for flat spots on the outside diameter, chipped edges, cracks, and pitting. Inspect the roller bushings for cracks and galling, and for fit in the rollers. Refer to the Table of Limits in Section XII. Inspect the roller pins for cracks and galling, and for fit in the roller bushings and tappets. Refer to the Table of Limits in Section XII.

d. VALVE TAPPET GUIDES.

(1) Inspect all valve tappet guides for cracks and for scoring of the inside diameter. Check the guides for wear on the inside diameter using plug gage (Tool No. 801071). Accept only tappet guides which permit insertion of the "GO" plug and which do not allow the "NO GO" plug to enter. *Do not use shim stock feeler gages* to measure the diametral clearance between a tappet and guide, since they cause scratches on the polished surface of the tappet and guide. Inspect all tappet guides for cleanliness of the oil holes and for cracks or galling of the attaching flange. Check the fit of the guides in the crankcase front section. Refer to the Table of Limits in Section XII.

e. PROPELLER SHAFT.

(1) Record the ratio of the propeller reduction gearing. Inspect the propeller shaft for cracks, particularly at the splines and in the location of oil holes. Inspect the threads at the thrust nut and propeller hub nut locations for mutilation. Inspect the propeller shaft splines for burrs, pitting, corrosion and excessive wear.

(2) Inspect the propeller shaft at the centering cones and thrust bearing locations for scoring, pitting, and galling. Check the outside diameter of the thrust bearing journal on the propeller shaft and the inside diameter of the thrust bearing inner race, using micrometers, to determine the fit. Refer to the Table of Limits in Section XII.

(3) Inspect all oil passages in the propeller shaft for cleanliness and freedom from obstruction, and inspect the radius at the end of the oil holes.

(4) Inspect the front and rear propeller shaft bushings for tightness, cracks, scoring and wear. Check the inside diameter of the bushings and the outside diameter of the crankshaft journals, using micrometers, to insure that the proper fits are obtained. Refer to the Table of Limits in Section XII.

(5) Inspect the thrust bearing spacer for cracks and condition of the inside and outside surfaces. Inspect the ring grooves for wear and for broken, cracked, or chipped lands. Inspect the lip on the spacer for condition of the seating surfaces and the thrust bearing contacting surface. Check the gap of the spacer rings. Refer to Figure 142. Check the inside diameter of the spacer and the outside diameter of the propeller shaft at the spacer location to determine the fit. Refer to the Table of Limits in Section XII.

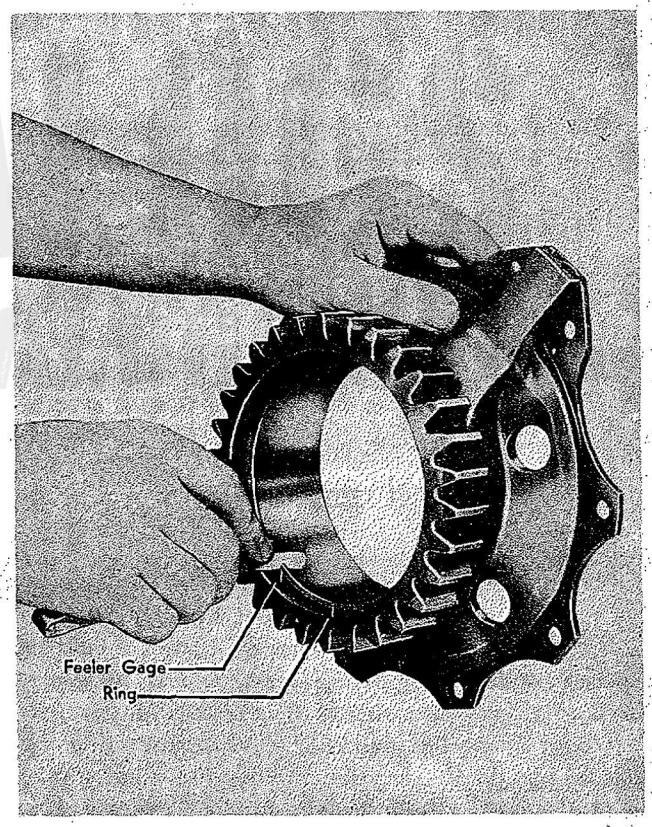

Figure 142—Measuring Ring Gap in Thrust Bearing Retaining Flange

(6) Check the reduction drive gear pinion bushings in the .666 (3:2) ratio propeller shaft pinion arms for tightness and condition of the inside surfaces.

Determine the diametral clearance between the bushings and the pinion journals. Refer to the Table of Limits in Section XII.

(7) Inspect the thrust nut for cracks, burrs, and mutilated threads. Inspect the ring grooves for wear and for broken, cracked, or chipped lands. Inspect the thrust nut front and rear faces for burring, or galling, and inspect the lugs for mutilation.

f. THRUST BEARING.

(1) Inspect the thrust bearing balls and races, using a magnifying glass, to determine if there are any cracks and if the surfaces are pitted or galled or have depressions worn in them by the balls. Inspect the retainer for wear and cracks. The presence of any one of these conditions warrants replacement of the thrust bearing. Do not inspect the thrust bearing by the magnetic type inspection method or by the use of etching fluid. Determine the axial looseness of the thrust bearing. Refer to Section VII, paragraph 4.

g. STATIONARY REDUCTION GEAR SUPPORT—.5625 (16:9) RATIO.

(1) Inspect the stationary reduction gear support used in .5625 (16:9) reduction geared engines for cracks. Check to make sure that the mounting flange at the front of the support has a good seating contact against its mating surface in the interior of the crankcase front section. It may be necessary to use prussian blue to make an accurate check. A good seating surface on this flange is particularly important in the location of the oil holes in the flange to prevent leakage. Inspect the inside diameter of the support for roughness or wear caused by the spacer oil seal rings. Inspect all oil passages for cleanliness and freedom from obstruction.

h. STATIONARY REDUCTION GEAR—.5625 (16:9) RATIO.

(1) Inspect the stationary reduction gear used in .5625 (16:9) reduction geared engines for pitted, chipped, cracked, or worn teeth. Inspect the tapped holes in the gear for burred or mutilated threads. Inspect the stationary reduction gear attaching cap screws for general condition, particularly at the threads and hexagonal head.

i. STATIONARY REDUCTION GEAR—.666 (3:2) RATIO.

(1) Inspect the stationary reduction gear used in .666 (3:2) reduction geared engines for cracks. Check the mounting flange of the stationary reduction gear for good seating contact against the front section in the same manner as the stationary reduction gear support in .5625 (16:9) reduction geared engines is checked. Inspect the inside diameter for roughness or wear caused by the spacer rings. Inspect the oil passages for freedom from obstruction. Inspect the gear teeth for cracks, pitting, chipping, or excessive wear. Inspect the stationary reduction gear attaching bolts and nuts for cracks, burrs at the locking circlet grooves on the bolt, condition of the flats on the nut and bolt heads, and condition of the threads.

j. REDUCTION DRIVE GEAR PINIONS.

(1) Inspect the reduction drive gear pinions for cracks. Inspect the oil passages for freedom from obstruction. Inspect the gear teeth for galling, pitting, chipping or excessive wear. Inspect the pinion journals for roughness, scoring and galling. Inspect the pinion bushings used in .5625 (16:9) reduction geared engines for galling, scoring and roughness, and determine the diametral clearance of the bushings on the carrier trunnions and in the pinions. Refer to the Table of Limits in Section XII. Inspect the flanges on these bushings for cracks, galling and chipping. Inspect the pinion attaching bolts for nicks or burrs on the bearing surfaces and for mutilation of the threads. Inspect the pinion bolt nuts used in .5625 (16:9) reduction geared engines for condition of the threads. Inspect the pinion guard ring for cracks and warping and for galled, pitted and corroded surfaces.

(2) Inspect the pinion carrier used in .5625 (16:9) reduction geared engines for cracks, particularly at the trunnions and attaching bolt holes. Inspect the condition of the surface which contacts the rear end of the propeller shaft. Inspect the trunnions for nicks, burrs and wear. Inspect the oil passages for cleanliness and freedom from obstruction. Inspect the bolts and nuts which attach the pinion carrier to the propeller shaft for nicks, burrs, and condition of the threads and heads.

k. REDUCTION DRIVING GEAR OR COUPLING.

(1) Inspect the reduction driving gear or coupling for cracks, and inspect the splines and internal and external teeth for pitting, chipping, mutilation, and excessive wear. Inspect the reduction driving gear or coupling nut for burred or mutilated threads, and inspect the front face of the nut and hexagonal faces for galling and mutilation. Check the general condition of the reduction driving gear or coupling nut lock screw.

l. TORQUE INDICATOR PARTS.

(1) If the engine is provided with a torque indicator, inspect the torque indicator parts in accordance with the following instructions: Inspect the torque arm for cracks, particularly at the splines. Inspect the recess in the end of the torque arm, which accommodates the torque indicator valve, for cracks, galling, scratching and excessive wear. Inspect the ball races of the torque arm and support for pitting and for depressions worn by the balls. Make a visual inspection of the balls for flats.

(2) Replacement of detail parts in the torque arm and support assembly is impossible because these parts are matched with precision. Consequently, if inspection of these parts reveals any of the defects described in the previous paragraph, the entire torque arm and support assembly must be replaced. For disposition instructions regarding these parts, AAF personnel will apply to Headquarters, Air Service Command, and Navy personnel will apply to Aviation Supply Office, Philadelphia, Penn.

(3) Inspect the torque indicator valve for cracks. Inspect the button at the end of the valve stem, and the stem itself, for galling, scratching or pitting caused by contact with the torque arm. Inspect the ring groove around the head of the valve for wear.

(4) Inspect the torque indicator housing and cover for cracks. Check the valve housing for tightness in the torque indicator housing, and inspect the valve housing sleeve for scratching or scuffing caused by the valve ring and for tightness in the housing. Inspect the oil passages in the housing for cleanliness. Check the general condition of the torque arm stop screw and lock nut. Inspect the tapped holes in the top of the torque indicator housing for condition of the threads, and check the thread condition of the nuts which attach the housing to the front section. Inspect also the bolts and nuts which attach the torque indicator housing cover to the housing.

(5) Inspect the torque indicator booster pump housing and cover for cracks. Inspect the booster pump gear recesses in the housing, and the bores in the housing and cover which accommodate the booster pump gear shafts, for burrs, scoring, chafing and wear. Inspect the oil passages in the housing and cover for cleanliness and freedom from obstruction. Inspect the thread condition of the cap screws which attach the booster pump housing to the torque indicator housing and the nuts which attach the booster pump housing to the front section. Inspect the booster pump gears for cracks and for pitted, galled, or excessively worn teeth.

4. CRANKCASE FRONT MAIN SECTION.

a. GENERAL.

(1) Inspect the crankcase main section front half for cracks, galling, and chafing, particularly at the parting surfaces and at the cylinder mounting pads. Check the condition of the threads in the main section front flange in which the crankcase front section attaching cap screws are installed. Check the condition of the threads in the cylinder hold-down cap screw holes in the cylinder mounting pads. Inspect the two hollow dowels in the lower part of the main section front flange, which constitute part of the oil scavenge passages, for tightness in the main section and for freedom from obstruction.

(2) Inspect the internal main section attaching lugs for bending, chafing marks, and cracks. Inspect the main section attaching nuts and bolts for cracks, straightness, burrs, and condition of the threads and hexagonal heads.

(3) Inspect the cam bearing ring for burrs, scoring, galling, and wear of bearing surface and flanges. Inspect the splines in the front flange for wear and mutilation. Inspect the oil passages and grooves for cleanliness. Check the diametral clearance between the cam and the cam bearing ring. Refer to the Table of Limits in Section XII.

(4) Inspect the front main bearing ring for scoring, galling, excessive wear, and tightness in the main section. Refer to the Table of Limits in Section XII. Inspect the bearing ring flange for cracks, and inspect the threads in the tapped holes in the flange for mutilation. Inspect the inside diameter of the flange for roughness and wear caused by the reduction driving gear spacer oil seal rings. Measure the inside diameter of the bearing ring and the outside diameter of the crankshaft front main bearing outer race, using micrometers, to insure that the proper fit is obtained Refer to the Table of Limits in Section XII.

(5) Inspect the reduction driving gear spacer for cracks. Inspect the ring grooves for wear and mutilation, and inspect the oil passages for cleanliness.

b. CAM AND CAM DRIVE.

(1) Inspect the cam for cracks. Inspect the cam lobes for pitting, galling, and scoring, and for wear or flat spots in the tappet roller tracks. Inspect the internal gear teeth on the cam for pitting, chipping, or excessive wear. Inspect the cam hub bore for scores, scratches and burrs.

(2) Inspect the cam drive gear bracket for cracks, nicks, and burrs. Check the cam drive gear bushing for tightness in the bracket and for scratches, burrs, and wear. Inspect the screws which attach the cam drive gear bracket, bracket spacer, and cam bearing ring spacer to the main section for wear and condition of the threads and head. Inspect the cam drive gear bracket spacer for scoring, galling, or mutilation of the contacting surfaces, and inspect the cam bearing ring spacer for the same conditions and for wear and mutilation of the splines.

(3) Inspect the cam drive gear and the intermediate governor drive gear for cracks and for pitted, chipped or broken teeth. Inspect the cam drive gear shaft for nicks, burrs, and condition of the bearing surfaces, and inspect the splines at the end of the shaft for mutilation and excessive wear. Check the fit of the cam drive gear shaft in the bushing. Refer to the Table of Limits in Section XII. Inspect the screws which attach the intermediate governor drive gear to the cam drive gear for condition of the threads. Inspect the cam drive gear spacer for wear and mutilation of the contacting surfaces and flange. Inspect the cam drive gear pinion for cracks and for pitted, chipped, and broken teeth and splines. Inspect the cam drive gear and pinion bolt and nut for burrs, cracks, straightness, and for mutilated threads, and inspect the slot in the head of the bolt for mutilation.

5. CRANKCASE REAR MAIN SECTION AND SUPERCHARGER FRONT HOUSING.

a. CRANKCASE REAR MAIN SECTION.

(1) Inspect the crankcase rear main section for cracks, galling, and chafing, particularly at the parting surfaces and at the cylinder mounting pads. Check the condition of the threads in the main section rear flange in which the supercharger front housing attaching cap screws are installed. Check the condition of the threads in the cylinder hold-down cap screw holes in the cylinder mounting pads. Inspect the four hollow dowels in the lower parts of the main section rear flange, which constitute part of the oil scavenge passages, for tightness in the main section and for freedom from obstruction. Inspect the internal main section attaching lugs for bending, chafing marks, and cracks.

(2) Inspect the rear main bearing ring for scoring, galling, excessive wear, and tightness in the main section. Measure the inside diameter of the bearing ring and the outside diameter of the crankshaft rear main bearing outer race, using micrometers, to insure that the proper fit is obtained. Refer to the Table of Limits in Section XII. If replacement of the rear main bearing ring is found to be necessary, the rear main section must be replaced. For disposition instructions regarding these parts, AAF personnel will apply to Headquarters, Air Service Command, and Navy personnel will apply to Aviation Supply Office, Philadelphia, Penn.

b. SUPERCHARGER FRONT HOUSING.

(1) Inspect the supercharger front housing for cracks, nicks, and chafing, particularly at the parting surfaces. Inspect the rear side of the web of the supercharger front housing for roughness, excessive wear, and depressions caused by chafing of the diffuser plate vanes.

(2) Inspect the finished surfaces for high spots around the studs. Inspect all studs for straightness, tightness, stretching, and condition of the threads. Order replacement of all studs that are bent, loose, stretched, or that show evidence of pulling.

(3) Inspect oil scavenge and breather passages in the supercharger front housing for cleanliness.

(4) Inspect the cap screws which attach the supercharger front housing to the crankcase rear main section for burrs, cracks, straightness, and condition of the threads and hexagonal head.

(5) Inspect the engine mounting lugs for cracks and excessive wear.

(6) Inspect the intake port threads for stripping, burrs and other mutilation. Inspect the intake pipe packing nuts for cracks and for stripped, burred, or mutilated threads. Inspect the lugs on the end of the nuts for bending and other mutilation.

(7) Inspect the impeller shaft bearing support and ring for cracks, smoothness of the contacting surfaces, and condition of the cap screw holes. Inspect the inside diameter of the support for roughness or wear caused by the impeller shaft front oil seal rings.

c. SUPERCHARGER FRONT HOUSING BREATHER.

(1) Inspect the breather or substituting cover for cracks and condition of the finished surfaces. Inspect the breather screen for clogging and mutilation. Check the operation of the breather relief valve by forcing the valve open. Visually inspect the condition of the valve seat.

6. SUPERCHARGER REAR HOUSING AND SUPERCHARGER REAR HOUSING COVER.

a. SUPERCHARGER REAR HOUSING.

(1) Inspect the supercharger rear housing for cracks, galling, and chafing, particularly at the parting surfaces and in the location of bolt holes and studs. Inspect the finished surfaces for scratches and nicks and for high spots around the studs. Inspect all studs for straightness, tightness, stretching, and condition of the threads. Order replacement of all studs which are bent, loose, stretched, or that show evidence of pulling. Inspect all oil passages in the supercharger rear housing for cleanliness and freedom from obstruction.

(2) Inspect the copper fuel venturi extension tube, which is spun into the lower part of the rear housing, for cracks, tightness in the housing, and for condition of the attaching bracket. Inspect the manifold pressure gage tube, which crosses the induction passage in the supercharger rear housing horizontally, for cracks and for tightness in the housing. Inspect the oil seal vent tube, which crosses the induction passage vertically, for cracks and for tightness in the housing. Inspect the umbrella type oil seal vent for cracks, mutilation of the threads, and obstruction of the vent passages.

(3) Inspect the rear impeller shaft sleeve for tightness in the rear housing and for roughness and wear on the inside diameter caused by the impeller shaft rear oil seal rings. Inspect the flange at the rear end of this sleeve for scoring, galling and excessive wear caused by contact with the impeller shaft gear washer.

(4) Inspect the impeller drive gear front bushing for tightness in the rear housing, and for scratches, burrs, and wear. Check the fit of the impeller drive gear front journal in the bushing. Refer to the Table of Limits in Section XII.

(5) Inspect the nuts which attach the supercharger rear housing to the supercharger front housing for mutilation of the threads and hexagonal faces.

b. DIFFUSER PLATE.

(1) Inspect the diffuser plate for cracks. Inspect the vanes for nicks, burrs, and other mutilation on the edges which contact the supercharger front housing. Inspect the inside diameter of the diffuser plate for scratches and roughness. Inspect the nuts which attach the diffuser plate to the supercharger rear housing for proper cotterpinning.

c. GUN SYNCHRONIZERS, DRIVE SHAFTS, AND SUPPORTS.

(1) Inspect the lower and upper plunger housings of each gun synchronizer impulse generator for cracks and for mutilation of the mounting surfaces. Inspect the threads in the plug holes in the lower and upper housings and on the plugs for mutilation. Inspect the studs in each lower housing for straightness, tightness in the housing, and condition of the threads. Inspect each laminated shim for bending, uniform thickness, and mutilation. Check the thread condition of the housing attaching nuts and cap screws.

(2) Inspect each plunger for cracks, galling, picking-up, and excessive wear. Check the fit of the plunger in the upper housing, and check the side clearance between the plunger and the interior of the lower housing. Refer to the Table of Limits in Section XII. Inspect the internal threads in one end of the plunger for mutilation and inspect the other end for condition of the spline. Inspect each cam follower roller for a free, true running condition, and for scoring, pitting, and excessive wear on the outside diameter of the roller. Check the side clearance between the rollers and plungers. Refer to the Table of Limits in Section XII.

(3) Inspect each cam for cracks, and for scoring, pitting, and excessive wear of the lobe. Inspect the tapered bore of the cam for a galled, burred, or picked-up condition. It is important that this bore be smooth to insure proper seating of the cam on the drive shaft upon tightening of the retaining nut. Inspect the threads in the nut for mutilation.

(4) Inspect each gun synchronizer impulse generator drive shaft and support for cracks. Inspect the spiral teeth on the shaft for pitting, chipping, and wear. Inspect the drive shaft journals for scratches, burrs, and wear. Inspect the tapered portion of the shaft, upon which the cam is installed, for galling and burring. Inspect the drive shaft thrust plug for galling and burring, and for tightness in the shaft. Inspect the threads on the end of the shaft for mutilation.

(5) Inspect the flange on each gun synchronizer drive shaft support for scoring, nicks, and scratches. Check the bushings pressed into the support for tightness in the support, and for scratches, burrs and wear. Check the fit of the shaft in the support bushings. Refer to the Table of Limits in Section XII.

(6) If the engine is not equipped with gun synchronizer impulse generators, inspect the gun synchronizer substituting covers which were removed from the gun synchronizer mounting pads on the supercharger rear housing for cracks and for condition of the finished surfaces. If extended type substituting covers are used, inspect the plug extension for cracks, and for excessive mutilation and wear which might cause oil leakage.

d. FUEL PUMP DRIVE SHAFT AND SUPPORT.

(1) Inspect the fuel pump drive shaft and the fuel pump drive shaft support for cracks. Inspect the spiral teeth on the shaft for pitting, chipping and wear. Check the fit of the shaft in the support bushings. Refer to the Table of Limits in Section XII. Inspect the drive shaft thrust plug for burring and galling and for tightness in the shaft. Inspect the splines on the inside diameter of the shaft for pitting, chipping, and mutilation.

(2) Inspect the flange on the fuel pump drive shaft support for scoring, nicks, and scratches. Inspect the bushings pressed into the support for scratches, burrs, and wear, and for tightness in the support. Check the condition of the leather oil seal in the flanged end of the support, and check the tightness of the seal in the support. Inspect the fuel pump substituting cover for cracks, and check the condition of the finished surface.

e. OIL FILTERS.

(1) CUNO OIL FILTER.

(a) Inspect the cartridge of the Cuno oil filter for bent or damaged cleaner disks and blades. Check the condition of the threads in the attaching nuts.

(b) Inspect the Cuno oil filter in the test fixture to insure that the automatic turning mechanism is functioning properly. Use for this purpose the same fixture which is used for cleaning the Cuno filter. To check the automatic motor head, plug the flushing oil inlet and outlet connections in the fixture, open the air outlet connection, and introduce an air pressure of 40 to 50 lb. per sq. in. into the air inlet connection. Refer to Figure 143. This causes the automatic turning mechanism to operate, which will be indicated by rotation of the indicator flag on the fixture and also by clicking of the valve mechanism in the filter head, which should be readily heard. If the flag does not turn and the clicking of the valve mechanism cannot be heard, the filter should be replaced. For instructions regarding the disposition of the replaced Cuno oil filter, the AAF personnel will contact Headquarters, Air Service Command, and Navy personnel will contact Aviation Supply Office, Philadelphia, Penn. If the valve mechanism can be heard clicking, but the indicator flag remains stationary although in proper engagement with the cartridge, that is usually an indication that the clutch is inoperative and requires repair. Do not operate the filter by air pressure any longer than is

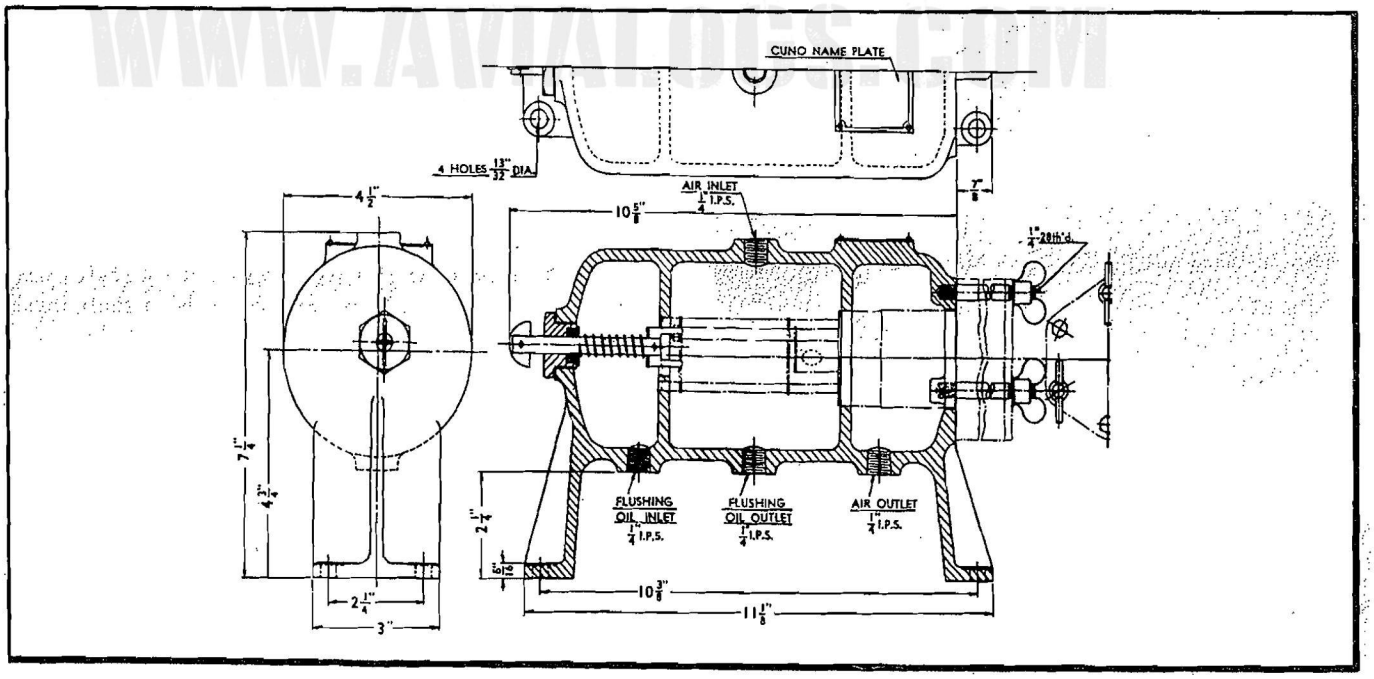

Figure 143—Cuno Test Fixture

necessary to check the operation of the automatic turning mechanism.

(c) Check the relief valve for satisfactory operation by using a rod to actuate the valve to determine if it is seating properly, if its operation is sluggish, or if it is sticking in an open or partially open position. This check is most important, since it is possible that a small amount of dirt may accumulate in back of the valve or on the valve, thereby making the valve operation sluggish or holding the valve in a partially open position. On Cuno filters which do not have a sludge tube at the relief valve opening, this check may be made, using the eraser end of a common pencil. Refer to Figure 144. On filters which are equipped with the sludge tube, a small rod may be inserted through the 1/8 in. dia. hole in the end of the sludge tube to perform this check. If sticking or improper seating of the relief valve is observed which cannot be corrected by cleaning of the valve assembly, it is recommended that the filter unit be replaced. For instructions regarding the disposition of the replaced Cuno oil filter, the AAF personnel will contact Headquarters, Air Service Command, and Navy personnel will contact Aviation Supply Office, Philadelphia, Penn.

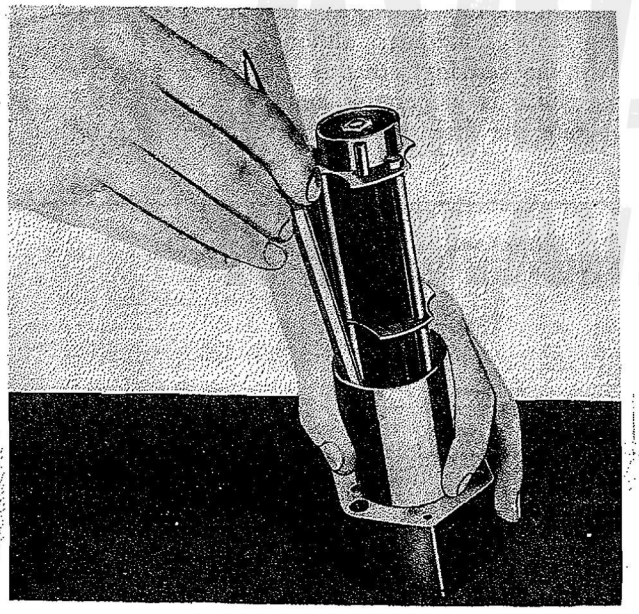

Figure 144—Checking Cuno Relief Valve Operation

(2) PRESSURE OIL STRAINER.

(a) Inspect the strainer for foreign material, also check the strainer for damage in the wire mesh.

(b) Check the seating of the ball type valve and the tension of the spring. Spring tension at 1.20 inches should be 1.65 pounds.

f. SUPERCHARGER DRAIN VALVE ASSEMBLY.

(1) Inspect the supercharger drain valve plug for mutilation and condition of the threads. Inspect the drain valve housing for condition of the finished surfaces and cracks, and check the condition of the threads. Inspect the disk for bending and mutilation and determine if the disk seats properly on the valve housing. Inspect the valve body for condition of the threads at each end of the body, for cracks, and for condition of the seat. Check the thread condition of the internal and external threads on the drain valve bushing. Inspect the venturi tube for cracks, bending, and tightness of the brazed tip in the tube. Inspect the orifice in the tip to insure that it is clear.

g. SUPERCHARGER REAR HOUSING COVER.

(1) Inspect the supercharger rear housing cover for cracks, galling, and chafing, particularly at the finished surfaces and in the location of bolt holes and studs. Inspect the finished surfaces for scratches and nicks and for high spots around tapped holes and studs. Inspect all studs for straightness, tightness, stretching, and condition of the threads. Inspect all oil passages in the rear cover for cleanliness.

(2) Inspect the oil pressure gage tube for cracks and for tightness in the rear cover.

(3) Inspect the accessory drive and starter shaft bushing, magneto drive shaft bushings, oil pump drive gear shaft bushing, dual accessory drive gear shaft bushing, and generator drive gear bushing for tightness in the rear cover, scratches, burrs, and wear. Check the fit of the respective shafts in these bushings. Refer to the Table of Limits in Section XII. Inspect to insure that one of the three slots in the accessory drive and starter shaft bushing is located directly opposite the oil passage leading from the Cuno oil filter recess. If a slot in the bushing is not lined up with the Cuno oil passage, order replacement of the bushing, since this condition may restrict the oil flow.

(4) Inspect the gun synchronizer drive shaft thrust bushings, if used, and the fuel pump drive shaft thrust bushing for burring and galling and for tightness in the rear cover.

(5) Inspect the intermediate impeller drive shaft rear bushing for tightness in the rear cover and for proper staking of the attaching screws. Inspect the inside diameter of the bushing for scratches, burrs, and wear. Check the fit of the impeller drive gear rear journal in the bushing. Refer to the Table of Limits in Section XII.

(6) Inspect the starter and generator substituting covers for cracks and condition of the finished surfaces.

(7) Inspect the oil vent connection for cracks and condition of the finished surfaces and internal threads.

h. ACCESSORY DRIVE AND STARTER SHAFT.

(1) Inspect the accessory drive and starter shaft for cracks, particularly in the location of splines and oil holes. Inspect the journals for scratches, burrs, and wear. Inspect the oil seal ring groove for burred, chipped, or worn edges. Inspect the splines on the anti-gear end of the shaft for pitting, chipping, and excessive wear. Inspect the internal splines in the large end of the shaft for chipping, corrosion, burring, and wear. Inspect the inside diameter of the shaft and all oil passages for cleanliness.

(2) Inspect the wall diameter of the recess in the gear hub for wear caused by the impeller shaft retainer oil seal ring. Direct that light ring marks be removed with crocus cloth, and that excessive wear be corrected by regrinding the wall to an oversize dimension as directed in Section VII, Par. 31A.

(3) Support the accessory drive and starter shaft on two identical V-blocks located under the impeller shaft front and rear bushing journals in such a way that the two oil flats are on top. This check should be performed on a surface plate. Inspect the shaft for twist, using a dial indicator, in the following manner: Turn the shaft until the rear flat is exactly level. Install the indicator in a surface gage and set the indicator to zero with the indicator finger contacting the rear flat. Move the indicator to the front flat and note the gage reading. The maximum permissible tolerance in height of these flats at manufacture is .010 in., and a greater difference than this in the height of the flats is an indication that the shaft is twisted. Reject a shaft that is found to be twisted.

(4) Inspect the accessory drive and starter shaft springs for cracks and for proper tension. Refer to the Table of Limits in Section XII. Inspect the spring retaining pins for cracks and scoring. Inspect the accessory drive gear rear plate for cracks, scratches, and scoring. Inspect the screws which attach the plate to the shaft for condition of the threads and screw driver slot. Inspect the gear for cracks and for pitted, chipped, cracked, and excessively worn teeth.

(5) Inspect the bronze accessory drive and starter shaft thrust ring for cracks, burring, scoring, and galling. Inspect the accessory drive and starter shaft spacer for cracks, and burring, scoring, galling, and roughness on the ends. Inspect the starter dog for cracks, inspect the splines for pitting, chipping, burring, and wear, and inspect the jaws for burred and broken edges and for scoring and galling. Inspect the oilite starter shaft oil seal packing for cracks, scratches, galling, picking-up, and wear. Inspect the starter shaft oil seal packing retainer for cracks and condition of the finished surfaces.

i. GENERATOR DRIVE GEAR AND OIL SEAL.

(1) Inspect the generator drive gear for cracks, for pitted, chipped, burred, and worn teeth and splines, and for burring, scoring, and roughness of the journal. Inspect the generator drive gear cup plug for tightness in the shaft.

(2) Inspect the generator drive oil seal retainer for cracks, scratches, and condition of the finished surfaces. Inspect the collars for cracks, scratches, scoring, and condition of the finished surfaces and splines. Check the fit of the end of the shaft in the collar. Refer to the Table of Limits in Section XII. Inspect the oilite retaining ring and flanged washer for cracks, scoring, and mutilation, and for condition of the lugs. Check the springs for cracks and for proper tension. Refer to the Table of Limits in Section XII.

j. MAGNETO DRIVE GEARS, SHAFTS, AND OIL SEALS.

(1) Inspect the magneto drive gears and shafts for cracks. Inspect the teeth on the gears for pitting, chipping, burring, and wear. Inspect the gear attaching screws and the tapped holes in the shafts for condition of the threads. Inspect the shafts for burrs, scores, picking-up, roughness on the journals. Inspect the spiral gear teeth on the shafts for pitting, chipping, burring, and wear. Inspect the internal splines in the end of the shafts for pitting, chipping, mutilation, and wear. Inspect the magneto drive gear shaft plug for tightness in the shaft.

(2) Inspect the parts of each magneto drive oil seal assembly in the same manner as the corresponding parts in the generator drive oil seal assembly are inspected.

k. OIL PUMP DRIVE GEAR.

(1) Inspect the oil pump drive gear in the same manner as the generator drive gear is inspected.

l. DUAL ACCESSORY DRIVE GEAR AND SHAFT.

(1) Inspect the dual accessory drive gear and shaft in the same manner as the magneto drive gears and shafts are inspected.

m. IMPELLER.

(1) Inspect the impeller for cracks in the hub and blades. Inspect the blades for scratches, burrs, roughness, and evidence of rubbing against the diffuser plate. Inspect the splines for burrs, pitting, galling, picking-up, and wear. Check the fit of the impeller on the impeller shaft by hand. Refer to the Table of Limits in Section XII. An impeller which

slides easily on the impeller shaft all the way should not be used, since excessive spline wear may result from such a condition. A proper fit is obtained with an impeller which may be installed approximately half way by hand.

n. IMPELLER SHAFT.

(1) Inspect the impeller shaft and integral gear for cracks, particularly in the location of the threads, splines, and gear teeth. Inspect the threads on the anti-gear end of the shaft for mutilation and general condition. Inspect the splines and gear teeth for pitting, burring, chipping, galling and wear. Inspect the impeller shaft front and rear bushings for burrs, scratches, galling, wear, and tightness in the shaft. Check the fit of the accessory drive and starter shaft in the bushings. Refer to the Table of Limits in Section XII.

(2) Inspect the front and rear impeller shaft oil sleeves for cracks, burring, and galling. Inspect the ring grooves for wear and for chipped, burred, and broken lands. Check the fit of the front and rear sleeves on the impeller shaft. Refer to the Table of Limits in Section XII. Inspect the impeller shaft gear bronze washer for cracks, scratches, burring, and scoring. Inspect the impeller shaft thrust ring steel washer for cracks, scratches, and burring, and for condition of the splines. Inspect the spherical thrust ring for cracks, nicks, burrs, and scores. Inspect the impeller shaft retainer for cracks, condition of the finished surfaces, and chipping, burring and wear of the ring groove. Inspect the shim for bending and mutilation. Inspect the impeller shaft front nut for cracks, nicks, and burrs, and for mutilation of the threads and slots.

o. IMPELLER DRIVE GEAR AND PINION (SINGLE-SPEED).

(1) Inspect the impeller drive gear and pinion and integral shaft for cracks, for pitted, burred, chipped, and worn teeth, and for burred, scratched. scored, and worn journals.

p. IMPELLER DRIVE (TWO-SPEED, DUAL HYDRAULIC CLUTCH TYPE).

(1) Inspect the low-speed impeller drive multiplate clutch sleeve for cracks, for roughness and wear on the inside diameter caused by the piston ring, for chipping, burring, and wear of the splines and for good seating contact of the flange on its mounting pad in the rear cover.

(2) Inspect the low-speed clutch piston for cracks, nicks, and scuffing, for chipping, burring, and wear of the splines, and for chipped, burred, and broken edges of the ring groove. Inspect the piston lock for tightness in the piston and for bending and mutilation of the lugs. Check the fit of the piston on the intermediate impeller drive shaft rear bushing. Refer to the Table of Limits in Section XII.

(3) Check the low-speed clutch release spring for cracks and for proper tension. Refer to the Table of Limits in Section XII. Inspect the low-speed clutch thrust spacer for cracks, and for burring, scoring, and scuffing of the contacting surfaces. Inspect the low-speed clutch thrust washer for cracks, for burring, scoring, and scuffing of the contacting surfaces, and for bending and mutilation of the lugs.

(4) Inspect the low-speed clutch disks and plates for cracks, scuffing, scoring, wear, and indications of overheating. Inspect the lugs on the plates and the internal splines on the disks for nicks and wear. Inspect the bronze facing on the disks for cracking, flaking, or breaking away from the steel. Order replacement of disks on which the bronze is cracked, flaked, or does not adhere to the steel.

(5) Inspect the low-speed clutch housing for cracks, for nicks and wear of the slots, and for good seating contact of the mounting flange on the flange of the low-speed clutch sleeve.

(6) Inspect the sun gear for cracks, for nicking, scoring, and scuffing of the contacting surfaces and inside diameter, and for burring, pitting, galling, and wear of the teeth and splines. Check the fit of the sun gear inside diameter on the intermediate impeller drive shaft bushing. Refer to the Table of Limits in Section XII. Inspect the intermediate impeller drive shaft bushing for burrs, scratches, galling, and wear, and for cleanliness of the oil holes. Check the fit of the intermediate impeller drive shaft in the bushing. Refer to the Table of Limits in Section XII.

(7) Inspect the intermediate impeller drive shaft for cracks, and for pitting, burring, chipping, and wear of the splines. Inspect the shaft also for roughness, scoring, and galling of the bearing journals, for nicks, burrs, and wear of the trunnions, and for cleanliness of the inside diameter and oil passages. Insure that the oil distributor plug is tight in the shaft and that the retaining pin is secure. Inspect the oil check valve for cracks and condition of the seat and check the oil check valve spring for cracks and proper ten-

sion. Refer to the Table of Limits in Section XII. Inspect the threads on the check valve plug and in the end of the oil distributor plug for mutilation.

(8) Inspect the pinions for cracks, for pitted, chipped, and worn teeth, for roughness and wear of the inside diameter, and for cleanliness of the oil holes. Inspect the pinion bushings for cracks, burrs, and scoring, and for cleanliness of the oil holes. Check the fit of the bushings on the trunnions and in the pinions. Refer to the Table of Limits in Section XII. Inspect the pinion gear horseshoe locks for wear and general condition.

(9) Inspect the intermediate impeller drive gear for cracks. Inspect the splines and internal teeth on the gear for pitting, chipping, mutilation, and excessive wear. Inspect the intermediate impeller drive gear bushing for burrs, scratches, scoring, and tightness in the gear. Check the fit of the intermediate impeller drive shaft in the bushing. Refer to the Table of Limits in Section XII.

(10) Check the high-speed clutch release spring for cracks and for proper tension. Refer to the Table of Limits in Section XII. Inspect the high-speed clutch disk retainer, disks, and plates for cracks, scuffing, scoring, wear, and indication of overheating. Inspect the internal splines on the disks and the external splines on the plates and retainer for nicks and wear. Inspect the lock wire groove in the outside diameter of the retainer for burrs and wear. Inspect the bronze facing on the disks for cracking, flaking, or breaking away from the steel. Order replacement of disks on which the bronze is cracked, flaked, or does not adhere to the steel.

(11) Inspect the high-speed clutch adapter for cracks, nicks, burrs, and scores, and for burring, pitting, galling and wear of the internal and external splines. Inspect the high-speed clutch piston for cracks, nicks, and scuffing, and for chipped, burred, and broken edges of the ring groove. Check the fit of the piston on the intermediate impeller drive shaft. Refer to the Table of Limits in Section XII. Inspect the impeller drive gear for cracks, for pitted, burred, chipped, and worn teeth and splines, and for a burred, scratched, scored, and worn journal. Inspect the lock wire groove in the gear for burrs and wear, and the slots in the web of the gear for mutilation and wear.

q. IMPELLER DRIVE (TWO-SPEED ROLLER CLUTCH TYPE).

(1) Inspect all gears for condition of the teeth, cracks, and abnormal wear. Examine the impeller drive gear for condition of the internal and external teeth, wear of the bearing journal, condition of the internal bushing, and cleanliness of the oil passages.

(2) Inspect the front and rear halves of the pinion cage for cracks, nicks, burrs, wear, cleanliness of the oil passages, condition of the splines, and for the condition of the bushing holes. Since the pinion bushings are the floating type, the bore should be free from roughness. Check the condition of the pinion journals for wear and smoothness.

(3) Inspect the intermediate impeller drive shaft for cracks, nicks, burrs, wear, condition of the bearing journals, and cleanliness of the oil passages. Inspect the intermediate impeller drive gear for condition of the splines and tightness of the bushing. Check the bushing for scores and wear.

(4) Examine the roller retainer for cracks, wear, scuffing, and galling. Inspect the intermediate impeller drive shaft thrust washer for scores and scuffing. Examine the cam surface for galling, scuffing, and wear. Check the cam splines for burrs, galling, and wear. Check the roller cage for wear, nicks, and burrs. Examine the rollers for flat spots, scuffing, nicks, and wear.

(5) Inspect the high speed clutch housing for cracks, wear and for the condition of the clutch plate lug slots. Check the clutch adapter for cracks, burrs, and condition of the splines. Examine the high speed clutch thrust washer and spacer for cracks, nicks, and wear. Inspect the clutch plates and disks for scuffing, cracks, wear, and dishing or warping. Check the clutch release spring for proper tension. Refer to the Table of Limits in Section XII.

(6) Inspect the piston for scuffing, cracks, nicks, and for the condition of the splines and piston ring groove.

(7) Inspect the high speed clutch sleeve for evidence of ring wear, nicks, and condition of the splines.

r. TWO-SPEED CLUTCH CONTROL.

(1) Inspect the two-speed supercharger clutch control housing or substituting cover for cracks. Inspect the inside diameter of the housing for nicks, scores, and wear. Inspect the valve for cracks, condition of the threads, cleanliness of the oil passages, and scratching, burring, and scuffing of the outside diameter. Inspect the spring for cracks and for proper tension. Refer to the Table of Limits in Section XII.

Inspect the control valve sleeve for cracks, cleanliness of the oil passages and grooves, and scratching, burring, and scuffing of the outside and inside surfaces. Check the fit of the valve in the sleeve and the sleeve in the rear cover. Refer to the Table of Limits in Section XII.

s. OIL PUMP BODY, GEARS, END PLATE, AND COVER.

(1) Inspect the oil pump body for cracks and condition of the finished surfaces. Inspect the studs for straightness, tightness, stretching, and condition of the threads. Inspect the diameter and the bottom of the gear recesses for nicks, scores, and wear. Inspect all oil passages in the oil pump body for cleanliness and freedom from obstruction. Inspect the drilled holes in the body which accommodate the oil pump drive shaft, the suction pump idler gear shaft, and the pressure pump idler gear shaft, for burrs, scoring, roughness, and wear.

(2) Inspect the oil pump drive shaft for cracks. Inspect the threads on the shaft for mutilation and general condition. Inspect the splines and gear teeth for pitting, burring, chipping, galling, and wear. Inspect the oil pump drive shaft journals for burrs, scratches, galling and wear. Check the fit of the journals in the oil pump body and in the oil pump body front end plate. Refer to the Table of Limits in Section XII. Inspect the oil pump drive coupling gear for cracks, and for pitting, burring, chipping, galling, and wear of the gear teeth and internal splines. Inspect the coupling gear nut for mutilation and burring of the threads, hexagonal faces, and cotterpin slots.

(3) Inspect the oil suction pump idler gear shaft for cracks, burring, scratching, galling, and wear. Check the fit of the shaft in the oil pump body and end plate, and check the fit of the suction pump idler gear on the shaft. Refer to the Table of Limits in Section XII. Inspect the oil suction pump idler gear teeth and inside diameter for cracks, pitting, burring, chipping, and wear.

(4) Inspect the oil pressure pump drive gear and idler gear for pitted, chipped, cracked, and worn teeth, and for burred, scratched, galled, and worn journals. Inspect the internal splines in the pressure pump drive gear for pitting, burring, chipping, and wear. Check the fit of the drive gear shaft in the oil pump rear cover. Refer to the Table of Limits in Section XII. Check the fit of the idler gear shaft in the oil pump body and in the cover. Refer to the Table of Limits in Section XII.

(5) Check the end clearance between all oil pump suction and pressure gears and the oil pump body front end plate and rear cover. Refer to the Table of Limits in Section XII.

(6) Inspect the oil pump body front end plate for cracks, and for scratching, nicking, scoring, and warping of the finished surfaces. Inspect the oil pump rear cover for cracks, for burrs, scoring, and roughness of the drilled holes which accommodate the oil pressure pump drive gear shaft and idler gear shaft, and for straightness, tightness, and thread condition of the studs.

(7) Inspect the oil pump inlet and outlet flanges for burring and mutilation of the finished surfaces and threads. Inspect the thread condition of the plugs and the holes in the oil pump body.

(8) Inspect the oil check valve body, which remains installed in the oil pump body, for pitting, burring, and scoring on the inside diameter.

t. OIL PUMP CHECK VALVE.

(1) Inspect the oil pump check valve, if used, for cracks, pitting, burring, and scoring, and for chipped, burred, and broken edges of the ring groove. Check the fit of the valve in the body. Refer to the Table of Limits in Section XII. Check the valve spring for cracks and for proper tension. Refer to the Table of Limits in Section XII. Inspect the check valve retainer for condition of the threads and hexagonal head.

u. OIL PRESSURE RELIEF VALVE.

(1) Inspect the oil pressure relief valve body for cracks, for pitting, burring, and scoring on the inside diameter, and for mutilation of the threads and slots. Inspect the valve for cracks, pitting, and scuffing. Check the fit of the valve in the body. Refer to the Table of Limits in Section XII. Check the relief valve spring for cracks and for proper tension. Refer to the Table of Limits in Section XII. Inspect the lock nut, adjusting nut, and cap for mutilation of the threads, and inspect the flanged washers for mutilation.

v. TACHOMETER DRIVE GEAR HOUSING, GEARS, AND COVER.

(1) Inspect the tachometer drive gear housing for cracks, and for scratching, nicking, scoring, and warping of the finished surfaces. Inspect the electric tachometer drive shaft front bushing for scratches, burrs, tightness in the housing, and wear. Check the fit of the electric tachometer drive shaft in the bushing. Refer to the Table of Limits in Section XII.

(2) Inspect the tachometer drive gear shaft and the mechanical and electric tachometer drive shafts for pitted, chipped, cracked, and worn gear teeth, and for burred, scratched, galled, and worn journals. Inspect the spring-loaded plug in the end of each of these shafts to insure that they move freely, and that the retaining pins are secure. Inspect the oil seal rings and retainers for mutilation. Inspect the splines on the end of the tachometer drive gear shaft for pitting, burring, and wear. Check the fit of the tachometer drive gear shaft in the oil pressure pump drive shaft. Refer to the Table of Limits in Section XII.

(3) Inspect the tachometer drive gear housing cover for cracks, and for scratching, nicking, scoring, and warping of the finished surfaces. Inspect the studs for straightness, tightness, and thread condition. Inspect the electric tachometer drive shaft rear bushing for scratches, burrs, tightness in the cover, and wear. Check the fit of the electric tachometer drive shaft in the bushing. Refer to the Table of Limits in Section XII.

(4) Inspect the mechanical tachometer drive shaft housing for cracks, nicks, scoring, and warping of the finished surface, and condition of the threads. Inspect the bushing for nicks, scratches, tightness in the housing, and wear. Check the fit of the mechanical tachometer drive shaft in the bushing. Refer to the Table of Limits in Section XII. Inspect the electric tachometer substituting cover for cracks and nicking, scoring, and warping of the finished surface.

w. DUAL ACCESSORY DRIVE HOUSING AND COVER.

(1) Inspect the dual accessory drive housing and cover for cracks, and for nicking, scoring, and warping of the finished surfaces. Inspect the studs for straightness, tightness, stretching, and condition of the threads. Inspect all oil passages for cleanliness and freedom from obstruction. Inspect all plugs and plug holes for thread condition.

(2) Inspect the intermediate drive shaft bushing, the idler gear bushing, and the upper and lower drive gear bushings in the dual accessory drive housing and cover for scratches, nicks, tightness in the housings, and wear. Check the fit of the respective shafts in the bushings. Refer to the Table of Limits in Section XII.

(3) Inspect the upper and lower drive substituting covers for cracks and nicking, scoring, and warping of the finished surface.

x. DUAL ACCESSORY DRIVE GEARS.

(1) Inspect the dual accessory driving gear, the dual accessory drive idler gear, and the upper and lower drive gears for cracks, pitted, chipped, burred, and worn teeth and splines, and burred, scratched, galled, and worn journals. Inspect the intermediate gear for pitted, chipped, burred, and worn teeth, and for mutilation of the threads in the attaching screw holes. Inspect the attaching screws for thread condition. Inspect the tongue coupling installed in the upper and lower drive gear shafts, if used, for tightness in the shafts and for mutilation of the slot.

7. CRANKSHAFT, MASTER AND ARTICULATED RODS.

a. CRANKSHAFT FRONT END.

(1) Inspect the crankshaft front end for cracks. Carefully inspect all surfaces of the crankshaft front end for scratches, nicks, and scores. Inspect the crankpin for burring, scratching, scoring, and picking-up, particularly in the location of the crankpin oil hole and the fillet at the front end of the crankpin. Inspect the crankpin for evidence of burning. Inspect for an out of round condition at both front and rear of the crankpin, using a micrometer, checking the crankpin diameter in each case at two locations 90 deg apart. Inspect the clamping surface at the rear of the crankpin for scratches, burrs, chafing, and evidence of turning of the crankshaft rear on the crankpin.

(2) Inspect the rear face of the front crankshaft cheek adjacent to the crankpin fillet for scratching, scuffing, and roughness of the highly polished finish on its surface. It is recommended that a finish of 13 to 15 micro-in. be maintained on this surface, which contacts the master rod end seal disk, in order to prevent mutilation and excessive wear of the disk. In appearance, a finish of 15 micro-in. is glossy, nearly mirror-like, and it is perfectly smooth to the touch. A reference block having a 15 micro-in. finish may be procured under Tool No. 801762, for comparison.

(3) Inspect the front and rear propeller shaft bushing journals for scratches, scuffing, galling, and wear. Inspect the crankshaft front main bearing journal for scratching and scoring caused by removal of the bearing inner race, which is a tight fit on the crankshaft. Check the outside diameter of the crankshaft front main bearing journal and the inside diameter of the front main bearing inner race, using micrometers, to insure that the proper fit is obtained. Refer to the Table of Limits in Section XII.

(4) Inspect the threads at the reduction driving gear nut location for burrs and mutilation. Inspect the splines at the reduction driving gear location for pitting, burring, scoring, galling, and wear.

(5) Inspect all oil passages in the crankshaft front end for cleanliness and freedom from obstruction. Inspect the crankpin oil tube in the interior of the crankpin for tightness.

(6) Inspect the crankshaft front end bushings, through which the counterweight pins pass, for pitting, chafing, scoring, picking-up and excessive wear on the ends of the inside diameter, and for tightness in the crankshaft cheek. Inspect the front counterweight for cracks, nicks, scratches and scores. Inspect the front counterweight bushings for tightness in the counterweight, pitting, chafing, scoring, picking-up, and excessive wear on the ends and inside diameter. Inspect the front counterweight pins for cracks, scratches, pitting, scuffing, pounding, and wear. Reject any pin that is spalled or under 1.0265 in. diameter. When the gritblasted surface of the pin has been removed during engine operation, the surface may be reblasted. Refer to Section VII, Par. 45 for gritblasting instructions. When lead plated gritblasted pins are encountered at overhaul, the plating need not be removed unless reconditioning of the surface is necessary. Lead plating of the counterweight pins is no longer required. Inspect the front counterweight stop for cracks, scratches, and nicks, and inspect the bolts and nuts which attach the stop to the crankshaft cheek for thread condition.

(7) Inspect the breather tube, if used, for cracks, burrs, scratches, scores and cleanliness of the oil holes and inside diameter. The front support of the tube should be inspected with the use of a magnifying glass to determine the condition of the soldered joint to the tube. Inspect the breather tube rear support or the substituting plug, whichever is used, for cracks, burrs, and scores, and inspect the lock screw for thread condition.

(8) Inspect the crankpin front plug for cracks, burrs, and scores, and inspect the lock screw for condition of the threads.

b. CRANKSHAFT REAR END.

(1) Inspect the crankshaft rear end for cracks. Carefully inspect all surfaces of the crankshaft rear end for scratches, nicks, and scores. Inspect the inside diameter of the crankpin hole for scratches, burrs, and chafing.

(2) Inspect the front face of the crankshaft rear adjacent to the crankpin hole for scratching, scuffing, and roughness of the highly polished finish on this surface. It is recommended that a finish of 13 to 15 micro-in. be maintained on this surface, which contacts the master rod end seal spacer, in order to prevent mutilation and excessive wear of the spacer. Use reference block (Tool No. 801762) for comparison to determine if the finish on this surface is satisfactory.

(3) Inspect the crankshaft rear main bearing journal for scratching and scoring caused by removal of the tight-fitting bearing inner race. Check the outside diameter of the crankshaft rear main bearing journal and the inside diameter of the rear main bearing inner race, using micrometers, to insure that the proper fit is obtained. Refer to the Table of Limits in Section XII.

(4) Inspect the threads at the crankshaft rear main bearing nut location for burrs and mutilation. Inspect the rear main bearing nut for burred or mutilated threads, and inspect the hexagonal faces of the nut for burring and mutilation. Inspect the rear main bearing nut lock screw for general condition.

(5) Inspect the internal splines in the recess in the crankshaft rear for pitting, burring, scoring, and wear. Inspect the accessory drive and starter shaft coupling for cracks and for pitting, burring, scoring, and wear of the external and internal splines.

(6) Inspect the crankshaft rear clamping cap screw for cracks and for burred or mutilated threads. Inspect the cap screw washer for cracks and galling on both faces.

(7) Inspect the bronze crankshaft rear end bushings, which accommodate the floating steel bushings, for pitting, chafing, scoring, picking out, and wear on the ends and inside diameter, and for tightness in the crankshaft rear. Inspect the floating steel bushings for cracks, pitting, chafing, scoring, picking-up, and excessive wear on the ends and both inside and outside diameters. Check the fit of the floating bushings in the bronze bushings, using a feeler gage. Refer to the Table of Limits in Section XII. Inspect the rear counterweight for cracks, nicks, scratches, and scores. Inspect the rear counterweight bushings for tightness in the counterweight, pitting, chafing, scoring, picking-up, and excessive wear on the end and inside diameter. For instructions on disposition of the counterweight pins refer to Par. 7, *a* (7) above. Inspect the rear counterweight stop for cracks, scratches, and nicks, and inspect its attaching bolts and nuts for thread condition.

c. CRANKSHAFT FRONT AND REAR MAIN BEARINGS.

(1) Inspect the crankshaft front and rear main bearing rollers and races, using a magnifying glass, to determine if there are any cracks and if the surfaces are pitted or galled. Inspect the retainers for wear and cracks. The presence of any one of these condi-

tions warrants replacement of a bearing. Do not inspect the crankshaft main bearings by the magnetic type inspection method or by the use of etching fluid. (Refer to ANTIFRICTION BEARINGS, paragraph 2, included at the beginning of this section.)

d. MASTER ROD.

(1) Inspect the master rod for cracks, scratches, nicks, and burrs. Inspect the rear face of the master rod hub for scratching, scuffing, and roughness of the highly polished surface which contacts the end seal spacer. Compare the finish on this surface with the 15 micro-in. reference block (Tool No. 801762). Inspect all oil passages in the master rod for cleanliness and freedom from obstruction.

(2) Inspect the piston pin bushing in the master rod for cracks, burrs, scratches, galling, wear, and tightness in the rod. Check the fit of the proper piston pin in the piston pin bushing in the master rod. Refer to the Table of Limits in section XII.

(3) Silver master rod bearings may leave a deposit of silver on the master rod bore. Remove this deposit with a cloth wheel and polish the bore very lightly before installing the bearing. Although some of the silver has left the bearing outside diameter and the surface appears rough, the bearing will be re-installed if it is in satisfactory condition in all other respects. Do not burnish a bearing slightly scored, scratched, or showing shallow oil erosion spots, as this results in high and low spots on the surface, causing a break down of the oil film and subsequent bearing failure. Do not order rework of any kind on this type bearing. If silver is removed to such an extent that the bearing shell is exposed, the bearing cannot be used.

(4) Inspect master rod bearing for cracks, scoring, overheating, flaking of the bearing material, fatigue cracks, foreign material in the bearing, and high spots in the bearing inside diameter. Order replacement of a bearing of which inspection shows any of the above conditions to be present. Overheating is evidenced by a red-orange color, possibly streaked with lead from the bearing lining. Fatigue cracks are seen as many short, irregular cracks running parallel to the bearing bore. Small gas holes in the bearing are permissible. Inspect the bearing also for tightness in the rod, condition of the splines at the front end, and wear of the inside diameter. Check the fit of the crankpin in the bearing. Refer to the Table of Limits in section XII.

(5) Check the horizontal alignment of the master rod by inserting bar (Tool No. 804022) in the piston pin bore when there is no bushing in the bore. If the bushing is in the piston pin bore use bar (Tool No. 83561). Insert bar (Tool No. 83560) in the center knuckle pin bore on all models except R-1820 -97 in which case bar (Tool No. 804655) is used. Install the master rod in the alignment checking fixture (Tool No. 803251), permitting the rod to hang freely, supported by the bar through the piston pin bushing hole resting on the V-blocks of the fixture. Using a dial indicator supported on a surface gage, take a reading at a point 3 in. away from the center line of the rod. Refer to Figure 145. Slide the dial indicator across the surface gage and take a reading at the same distance on the other side of the bar. The misalignment of the piston pin bushing and master rod bearing bores, checked in this manner, should be no greater than .004 in. Check the master rod for vertical alignment while the rod is supported in the fixture by measuring the clearance between one end of the bar which is inserted in the knuckle pin hole and one rail of the fixture, when the other end of the bar is contacting the other side rail. Refer to Figure 146. The master rod twist, checked in this manner, should be no greater than .010 in.

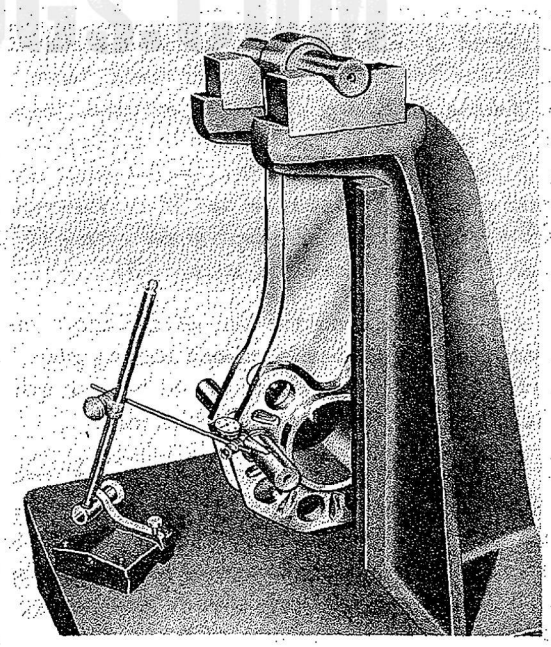

Figure 145—Checking Horizontal Alignment of Master Rod

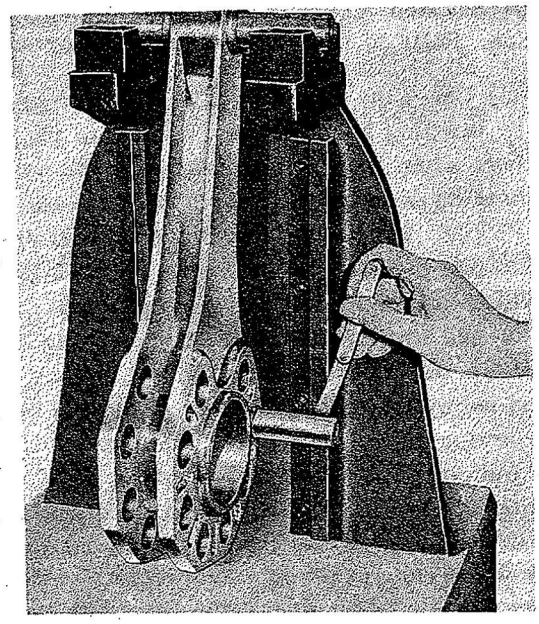

Figure 146—Checking Master Rod Vertical Alignment

(6) Inspect the knuckle pin holes in flanges of the master rod for scratches and galling. Inspect the inside surface of both flanges adjacent to the knuckle pin holes for galling and chafing.

(7) Inspect the knuckle pin locking plate for cracks, burrs, condition of splines, bending of the lugs, and cleanliness of oil passages. Inspect knuckle pin lock screws for cracks, condition of the threads, and cleanliness of oil holes. Inspect master rod end seal disk and spacer for cracks, mutilation, wear, burrs, scores, and flaking of plating or bearing material. Inspect the end seal spring for proper tension by placing the spring on a horizontal surface. Place a flat plate over the spring and place weights on the plate. Determine the total weight required to compress the spring to .32 in. Refer to Table of Limits in section XII.

(8) End wear on the tips of the inner diameter splines of the knuckle pin splined locking plate, where contact is made with the master rod bearing splines, is permissible to a maximum of 0.020 inch.

(9) Any combination of wear on the side faces of any one of the master rod bearing splines that does not exceed a maximum of 0.020 inch is acceptable. End wear on the portion of the master rod bearing splines, that is in contact with the knuckle pin locking plate, is permissible to a maximum of 0.010 inch.

(10) Inspect the oil seal discs thrust face for evidence of a dishing condition. Place a straight edge across the face of the disc. Determine if the dishing condition is present. Replace all discs that show evidence of a dishing condition.

e. ARTICULATED RODS.

(1) Inspect the articulated rods for cracks, scratches, nicks, burrs, and bending. Do not use nor attempt to straighten a bent rod. Inspect the piston pin bushing and the knuckle pin bushing in each rod for cracks, burrs, scratches, galling, wear, and tightness in the rod. The horizontal and vertical alignment of the articulated rods is checked the same as that of the master rod. Use alignment checking fixture (Tool No. 803251), bar (Tool No. 804022) in the piston pin bore and bar (Tool No. 804419) in the knuckle pin bore if no bushings are in rod. When bushings are in rod use bar (Tool No. 83561) in piston pin bore and bar (Tool No. 84304) in knuckle pin bore. Check the fit first of the piston pins and knuckle pins in their respective rods. Refer to the Table of Limits in section XII.

8. CYLINDERS AND PISTONS.

a. CYLINDERS.

(1) Inspect the rocker box cover parting surfaces and the exhaust pipe flange mounting pad on all cylinder heads for scratches and nicks and for high spots around the studs. Inspect the studs in these mounting pads for straightness, tightness, stretching and condition of the threads. Inspect the rocker arm bolt bosses in all rocker boxes for cracks, and for nicks and burrs in the spherical washer locations. Inspect the rocker arm bolt bushings for wear on the inside diameter and for tightness in the bosses. Inspect the intake pipe flange mounting pad for scratches and nicks and high spots around the screw bushings. Inspect the intake pipe flange attaching screw bushing in the mounting pad, and inspect the air deflector attaching screw bushings in the outside of the rocker boxes and in the intake pipe flange mounting pad, for mutilation of the threads and for tightness in the cylinder head.

(2) Carefully inspect all the cylinder heads visually, both internally and externally, for cracks. Order replacement of any cylinder in which the head may be found to be cracked. Inspect the cylinder heads for cracked or broken fins. It is permissible to rework cracked or broken fins by profiling to the depth of the crack, provided the crack does not extend into the dome of the cylinder head, and provided the total

amount of fin metal removed in this manner does not exceed 14 sq in. per cylinder. Order replacement of any cylinder in which a fin crack is found to extend into the cylinder head dome, or in which more than 14 sq in. of fin metal must be removed to repair cracked or broken fins.

(3) Inspect the exhaust and intake valve guides for tightness in the head, backing out, cracks and scratching or scoring of the inside diameter. Inspect the location at the inner end of the exhaust valve guide and the adjacent part of the valve guide boss in the exhaust port for burning and pocketing. Inspect

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the inside diameter of the valve guides for wear, out of round, and bell-mouthing at the ends, using the flat plug gages (Tool No. 82664 for exhaust valve guides and Tool No. 800574 for intake valve guides). Make this check at both ends of the valve guide. The gages are designed just larger than the maximum permissible diameters. If it is possible to insert the gage in the guide, the guide should be replaced. Make this check at two locations 90 deg from each other, at each end of the guide, to indicate an out of round condition.

(4) Inspect the exhaust and intake valve seat inserts in all cylinders for pitting, burning, and concentricity with their valve guides. Regrind or replace all valve seat inserts which are excessively pitted or burned. An insert which is pitted to such an extent that it cannot be fitted for further use by grinding must be replaced.

(5) If the bluing gage (Tool No. 800250 for exhaust valve seats or Tool No. 800249 for intake valve seats) is used to check concentricity, insert a feeler gage between the seat and the gage at a point diametrically opposite from the point of contact between the seat and the gage. If the clearance measured in this manner is greater than .0075 in., it is recommended that a new valve guide be installed.

(6) Inspect the condition of the threads in the spark plug inserts in all cylinders.

Figure 147
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dated April 15, 1944

(8) Inspect the cylinder barrel for bent, cracked, and broken skirts and fins. Replace any cylinders with a bent or cracked skirt, or with barrel fins broken at the root of the fin.

(9) Inspect the cylinder mounting flange for cracks, nicks and warping. Failure of cylinder hold-down cap screws may occur if cylinders having warped flanges are used. A bluing gage (Tool No. 800843) and cylinder flange hand lap (Tool No. 800985) are used for test and truing of warped flanges. Inspect the cylinder hold-down cap screws for cracks and for mutilated threads and hexagonal heads.

(10) Inspect the inside diameter of the cylinder barrel in all cylinders for corrosion, scores, ring wear, minimum and maximum diameter, out of round, and taper. Corrosion is evidenced by rust or pit marks. Ring wear is evidenced by ridges or grooves near the top and bottom of the barrel at the ends of the piston travel.

(11) Use cylinder bore gage (Tool No. 800641)

to measure the minimum and maximum diameter of the cylinder bore, and to check the bore for out of round and taper. This gage is used in connection with a master ring gage (Tool No. 84757) which has an inside diameter equal to the cylinder bore standard diameter of 6.125 in. Insert the cylinder bore gage in the master ring gage, and set the indicator to zero. Insert the cylinder bore gage in the cylinder in the plane of the cylinder mounting flange so that the indicator spindle contacts the thrust and anti-thrust sides of the cylinder wall. Refer to Figure 148. Take a reading at this position, then turn the gage and take another reading 90 deg from the first position. The difference between these two readings is equal to the cylinder bore out of round in this plane. Repeat this procedure in a plane approximately half way up the cylinder barrel, and again at the head end of the cylinder barrel, where the ring wear is greatest.

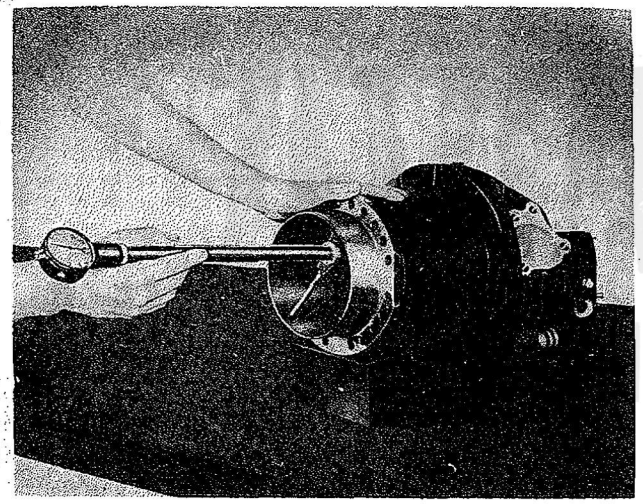

Figure 148—Checking Cylinder Bore Dimensions

(12) Record the minimum and maximum diameters of the cylinder bore, and the maximum out of round in the three planes checked. Subtract the maximum reading obtained at the head end of the cylinder bore from the minimum reading obtained at the flange end to determine the taper of the cylinder bore. (Refer to the Table of Limits for the maximum permissible limits of cylinder bore out of round, wear, and taper). Cylinders which are scored on the inside diameter or which are worn beyond the permissible limits must be reground to an oversize bore, or if barrel replacement is necessary, AAF activities will contact Headquarters, Air Service Command, and Naval activities will follow procedure outlined in Navy General Bulletin No. 8.

NOTE

Cylinders used in R-1820 engines are provided with a choke bore at the head end of the barrel. This end of the barrel has a smaller diameter than other parts of the barrel to provide for ring wear, which is greatest in this location. Consequently, at the first or second overhaul of a new engine or of an engine using new cylinders, the maximum diameter of the choke bore may be less than the minimum inside diameter at the mounting flange location. This condition is normal for choke bore cylinders. Cylinder bore taper is undesirable only when the diameter at the head end of the barrel is larger than the diameter of other parts of the barrel, indicating excessive ring wear at the head end.

b. VALVES.

(1) Inspect exhaust and intake valves for cracks. Do not inspect exhaust valves for cracks by the magnetic type method of inspection. Inspect the valve head, face, stem, and tip for pitting, scores, burning and wear. Refer to Figure 149, which shows the area in which valve stem pitting is objectionable. Inspect the edges of the split lock groove for wear, burrs, and chipping. Measure the valve stem diameter, using a micrometer, to determine if the proper fit of the valve in its guide is obtained. Refer to the Table of Limits in Section XII.

(2) Inspect the valve face for warping. To do this, place the valve horizontally on a V-block on a square surface, so that the valve head projects over the end of the block, and the valve tip contacts a stop at the other end of the block. Install a dial indicator in a surface gage, and adjust the indicator finger to contact the valve face. Turn the valve, keeping the tip in contact with the stop, and observe the runout on the indicator. A warped valve head will cause burning of the valve face.

(3) Inspect exhaust valves for minimum face diameter, tip wear and stretch using the exhaust valve limit gage (Tool No. 800353). Push the pointed pin on the gage against the spring, and place the valve to be checked in the V-blocks of the gage so that the locating pins in the gage contact the upper radius of the lock groove in the valve stem. Release the pointed pin, allowing the point to contact the underside of the valve head adjacent to the inner diameter of the valve

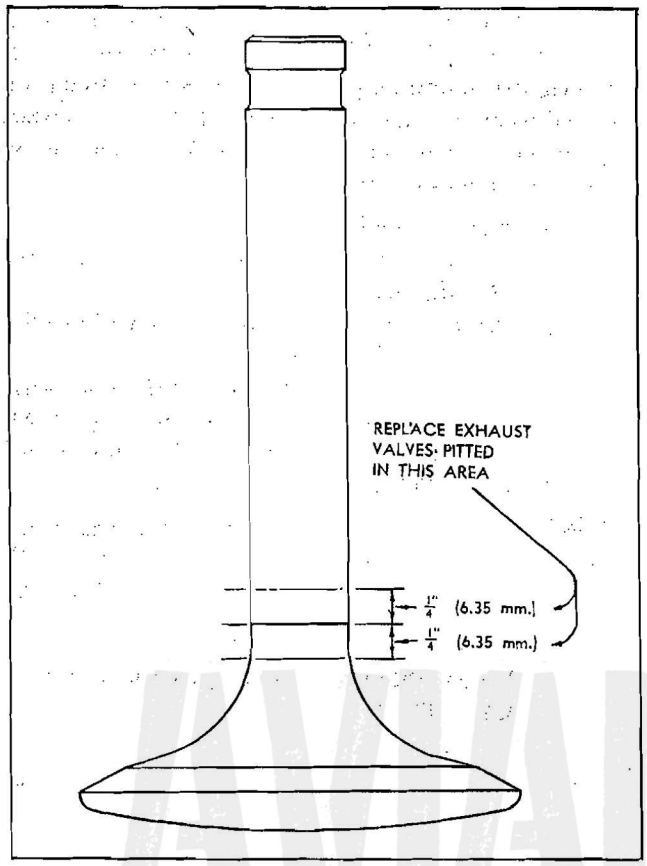

Figure 149—Valve Stem Area Where Pitting is Objectionable

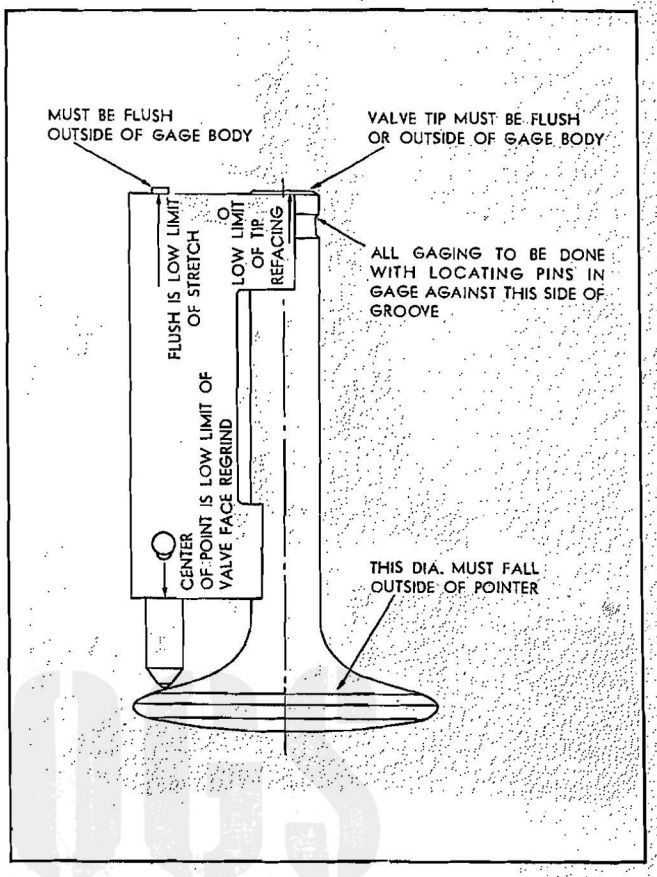

Figure 150—Checking Exhaust Valve Using Limit Gage

face. The minimum permissible diameter of the valve face is indicated by the point of the pin. The inner face diameter must fall outside of the point of the pin. The limit of wear or refacing of the tip of the valve stem is indicated by the end of the gage body. The tip of the valve stem must fall outside of, or be flush with, the end of the gage body. The maximum permissible valve stretch is indicated by the upper end of the pin on the gage relative to the end of the gage body. The end of the pin must fall outside of, or be flush with, the end of the gage body. Refer to Figure 150.

CAUTION

Exhaust valves are filled with sodium, which is inflammable in the presence of water. To insure against fire and possible personal injury as a result of this condition, extreme care should be exercised when disposing of exhaust valves which are not fit for further use. Purchasers of scrap equipment should be advised of this condition.

(4) Inspect intake valves for minimum face diameter and tip wear, using the intake valve limit gage (Tool No. 800353), in the same manner as described for exhaust valves. It is not necessary to inspect intake valves for stretch.

(5) Inspect the split locks for cracks, burrs, and wear. Inspect the valve springs for cracks and for proper tension. Refer to Figure 151. Reject any spring whose tension is not within the specified limits. Refer to the Table of Limits in this section. Inspect the valve spring washers for cracks, burrs and wear.

c. PISTONS.

(1) Inspect all pistons for cracks, particularly in the location of the piston pin bosses, ring lands and skirts. Inspect the piston heads for burning. Inspect the ring grooves for cleanliness, burrs, and for cracked or chipped edges. Inspect the drilled holes in the fourth and fifth ring grooves for cleanliness. Inspect the ring lands and the piston skirts for scratches, scores and nicks.

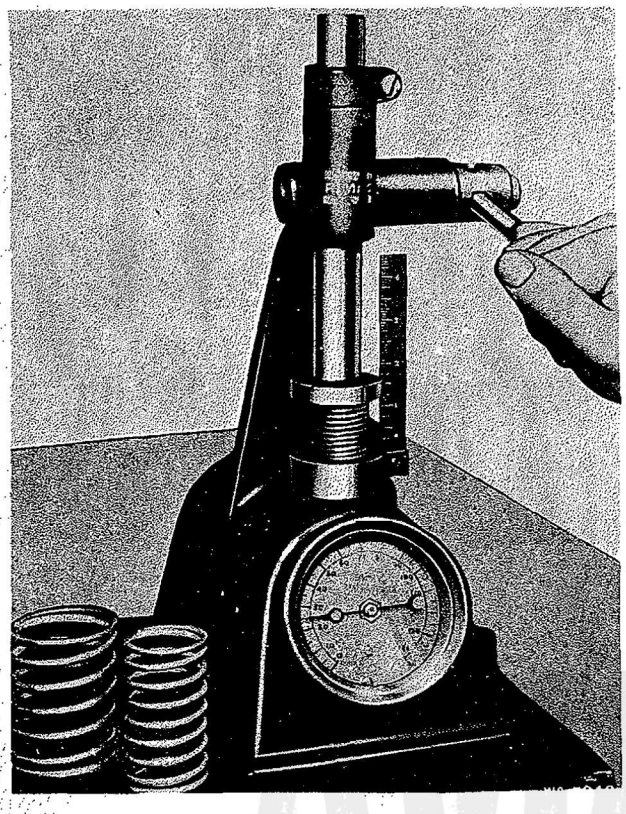

Figure 151—Testing Valve Spring Tension

(2) Measure the diameter of the pistons, using a micrometer located midway between the bottom ring groove and the fifth ring groove, on the thrust and anti-thrust diameter. Compare this diameter with the diameter of the cylinder bore to determine if the proper fit of the piston in its cylinder is obtained. Refer to the Table of Limits in Section XII.

(3) Inspect the piston pin holes in the piston for scratches, scores, and wear. Check the fit of the piston pin in these holes. Refer to the Table of Limits in Section XII. Inspect the piston pin retainer grooves for worn edges and general condition.

NOTE

The transverse depressions worn in the retainer grooves by the coils of the spring retainers are normal, and are not dangerous unless the depressions are worn too deep. The allowable depth of these depressions prior to the rejection of a piston as a result of this condition is one-half the diameter of the wire of the coil spring retainer. Do not attempt to remove these depressions by polishing or machining the retainer grooves.

(4) Inspect the piston pin by means of the magnetic type inspection. Examine the outside diameter for any magnetic indications. Inspect for scoring. Redip the pin and using a dental mirror, inspect the inner surface of the pin. Piston pins are unservicable if any of the following conditions are noted:

(a) Cracks of any kind.
(b) Indication of inclusions on the I.D. or chamfer of the pin.
(c) Inclusions extending to the surface within .0625 inch of the edge of the pin.
(d) Inclusions extending to the surface on areas not mentioned in (b) and (c) in excess of .250 inch and/or the sum total of all such inclusion exceed .750 inch.

Check pin for out of round by using a micrometer and inspect for straightness, using a dial indicator at the center of the pin while turning the pin in V-blocks. See Figure 152.

9. ROCKER BOX COVERS, ROCKER ARMS, PUSH RODS, AND PUSH ROD HOUSINGS.

a. ROCKER BOX COVERS.

(1) Inspect all rocker box covers for cracks and for scratching, burring, and warping of the parting surface.

b. ROCKER ARMS.

(1) Inspect all rocker arms for cracks.

CAUTION

Remove the rocker arm bearing before inspecting a rocker arm by the magnetic type method of inspection.

(2) Inspect the radius between the rocker arm hub and the roller arm for scratches, nicks, and chafing. The presence of any of these conditions is an indication that interference is occurring between the rocker arm and the valve spring upper washer or valve spring. Carefully inspect for cracks in this location. Another check should be made at assembly of the rocker arms in the cylinders to insure that no interference exists at this location. Instructions for making this check are included in Section IV.

(3) Inspect the rocker arm rollers for flat spots on the outside diameter, chipped edges, cracks, and pitting. Check the end clearance of the roller and the roller hub in the yoke of the rocker arm. Refer to the Table of Limits in Section XII. Check the wear of these parts by hand, moving the roller at right angles to the pin. Inspect the pin for tightness in the arm.

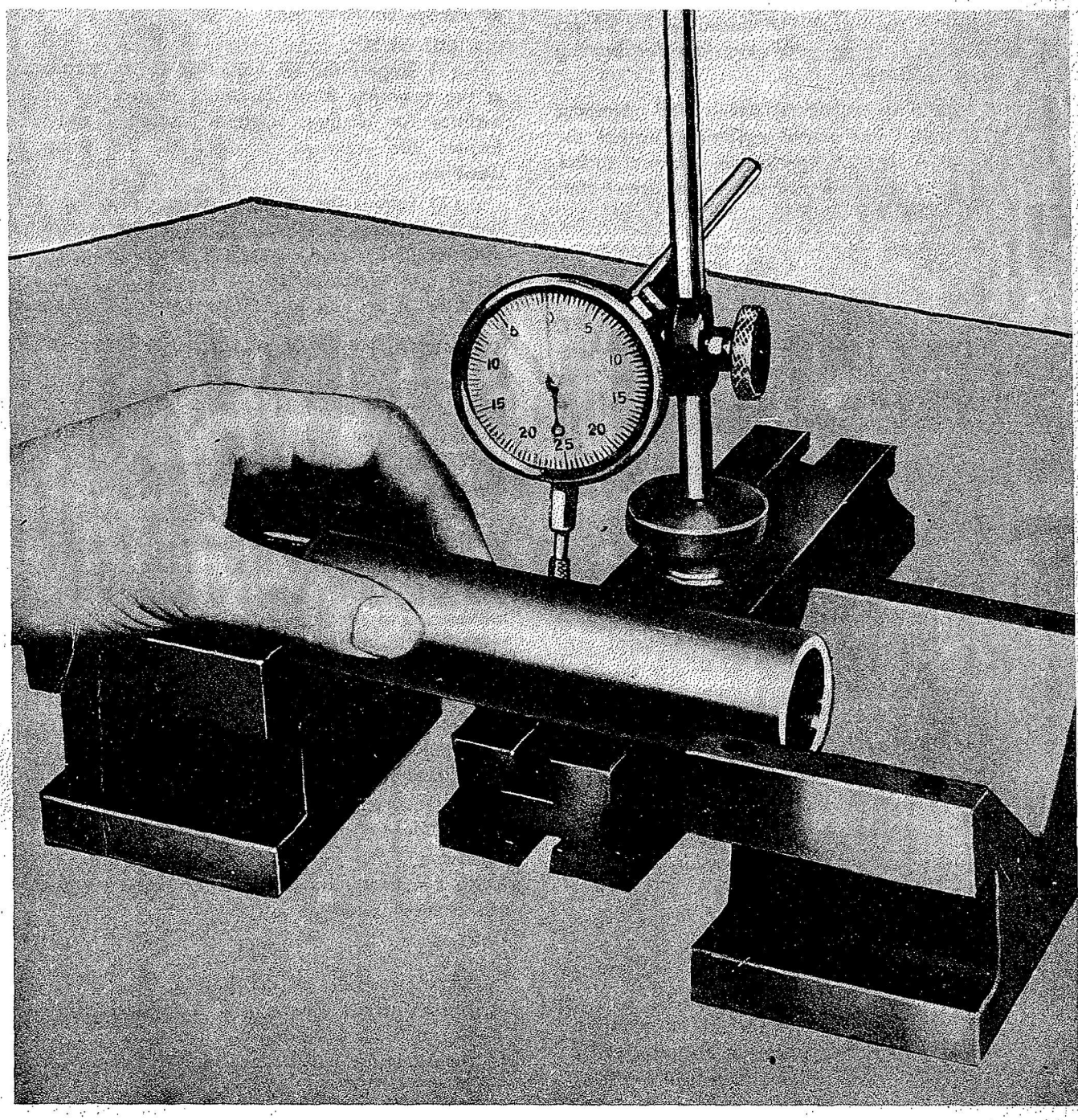

Figure 152—Checking Piston Pin Alignment

(4) Inspect the oil passages in the rocker arms for cleanliness.

(5) Inspect the bearing bore in the rocker arm for excessive scratching, scoring, galling, and wear. Measure the diameter of the bearing bore and the outside diameter of the bearing outer race, using micrometers, to determine if the proper fit is obtained. Refer to the Table of Limits.

(6) Inspect the rocker arm threads at the adjusting screw and clamping screw locations for burring and general condition.

(7) Inspect the adjusting screws and clamping screws for cracks and thread condition. Inspect the adjusting screws also for wear of the spherical socket, nicks, and burrs on the flange and screw driver slot, and cleanliness of the oil hole.

(8) Inspect the rocker arm bearings in accordance with instructions included at the beginning of this section under paragraph 2.

(9) Inspect the rocker arm bolts for cracks, nicks, wear, and condition of the threads. Particular attention should be given to the threaded portion of the bolt during magnetic inspection since the majority of the cracks which may exist will be located at the root of the threads.

c. PUSH RODS.

(1) Inspect all push rods for cracks, bending, and cleanliness of the oil passage. Inspect the ball ends for cracks, looseness in the rod, and excessive wear. Do not attempt to remove the ball ends.

d. PUSH ROD HOUSINGS.

(1) Inspect the push rod housings for cracks and dents. Inspect for indications of push rod interference. Inspect the hose clamps for cracks and condition of the bolts and nuts.

10. INTAKE PIPES, AIR DEFLECTORS, OIL SUMP.

a. INTAKE PIPES.

(1) Inspect intake pipes for cracks and dents. Order replacement of a cracked or mutilated intake pipe. Inspect the intake pipe flange for cracks, nicks burrs, and condition of the finished surface. Inspect the intake pipe flange attaching screws for thread condition.

b. AIR DEFLECTORS. (Metal and Plastic)

(1) Inspect the cylinder head and intercylinder air deflectors for cracks, dents, chafing, tightness of the rivets and thread condition of the attaching screws and nuts.

(2) Inspect the inter-cylinder air deflectors also for deterioration, tearing, and wear of the neoprene pads. Inspect the inter-cylinder air deflector upper grommet, plate, and attaching nut for deterioration of the gormmet, cracks and mutilation of the plate, and thread condition of the attaching nut. Inspect the inter-cylinder lower clamp, bolt, nut, and spacer for cracks, bending, and chafing of the clamp, thread condition of the bolt and nut, and cracks and mutilation of the spacer.

c. OIL SUMP.

(1) Inspect the oil sump for cracks, particularly at the mounting flange locations. Inspect the finished surfaces for chafing, scratches, trueness, and wear. Inspect the scavenge passages in the sump for cleanliness.

(2) Inspect the oil sump strainer plug for condition of the screen and mutilation of the threads and plug head. Inspect the magnetic plug for thread condition and mutilation of the head. Inspect the other oil sump plugs and plug holes for thread condition.

11. IGNITION WIRING MANIFOLD.

a. Inspect the inside diameter of all parts of the ignition wiring manifold assembly, particularly at the connections, for nicks, burrs, and abrasions which could tear or otherwise damage the wire cable insulation.

b. Inspect the halves of the ignition wiring manifold ring and the manifold elbows for cracks, particularly at the outlets and at the mounting bracket locations. Inspect the manifold halves and elbows also for dents, and condition of the threads at the outlets. Inspect the manifold supports and clips for cracks and mutilation.

c. Inspect the main magneto conduits, the cross-over conduit, and the spark plug conduits for abrasion and separation of the shielding braid, and condition of the threads and knurled and hexagonal union nuts. Inspect the spark plug terminal elbows for cracks and mutilation of the threads and union nut.

d. Inspect the magneto outlet front flanges and elbows for cracks, condition of the threads, and trueness of the finished surfaces.

NOTE

After inspection, all steel engine parts will be covered with a light coat of corrosion preventive mixture consisting of one part engine corrosion preventive compound, Specification No. AN-VV-C-576, to three parts lubrication oil, grade 1065A, Specification No. AN-VV-O-446.

12. FLUORESCENT PENETRANT METHOD OF INSPECTION.

a. GENERAL. The fluorescent penetrant method of inspection is a non-destructive means of testing non-ferrous parts for cracks and defects which have an opening to the surface. This inspection should include the testing of the parts, the tabulation of the nature and extent of the defects found, and the final decision as to the suitability of the parts for further service. Inspectors in the field should be specialists who have been thoroughly trained to evaluate correctly the indications which may be encountered.

b. DESCRIPTION. The process consists of immersing the part to be inspected in an oil penetrant that will fluoresce when exposed to black light (ultra-violet) rays (figure 6-153). After immersion the part is drained, then it is washed with water to remove the penetrant from the surface. The part is allowed to stand to permit the water to drain and the penetrant to seep from any possible defects. This is followed by a visual inspection under black light rays.

c. EQUIPMENT. The recommended black light (ultra-violet) units are a Westinghouse or General Electric mercury projector lamp Nr. CH-4 (spot) or EH-4 (flood), using a Corning 5CVX-RDL filter or its equivalent.

d. The recommended oil penetrant is Zyglo ZL-1, and the recommended blotting agent is Zyglo developing power ZP-2. The tank for the penetrant should be equipped with a thermostat-controlled heating unit to maintain the temperature at 49°C (120°F.). The oil penetrant is a skin irritant, and provision should be made to handle parts by mechanical means. The operator should wear rubber gloves.

e. PROCEDURE. Thoroughly clean and degrease each part to be inspected. Using a black light unit, check the efficiency of the cleaning operation as grease, oil, sealing compound and many other substances fluoresce under black light.

f. Immerse the part in the penetrant for the amount of time shown in the table in paragraph *l.*

NOTE

It is important that the operator allow the proper draining time for each part to insure maximum penetration of the oil penetrant. (Refer to paragraph *l.*)

g. Remove the part and allow it to drain in several different positions. This will minimize the dragout losses of penetrant and allow continued penetration into cracks or defects during the draining of the part.

CAUTION

Aluminum and magnesium parts should be fluorescent inspected before paint and varnish is stripped, since the stripping operation tends to obscure indications.

h. Using a spray nozzle and a pressure of 40 to 50 pounds per square inch, wash the part thoroughly with warm water to remove the penetrant from the surface. Avoid excessive washing as this has a tendency to remove the oil penetrant from the cracks or defects.

i. Allow the part to stand for the period shown in the table in paragraph *l.* This will allow the penetrant to seep from the cracks and defects. Blow off any water remaining with low pressure air (25 pounds per square inch).

j. Subject the part to a visual inspection under black light. The presence of porosity, cracks or other voids open to the surface, is indicated by the fluorescence of the penetrant.

k. If an area of a part fluoresces because of the presence of some foreign substance having a fluorescent property, dust the area lightly with a blotting agent (Zyglo developing power ZP-2). The blotting agent, an opaque non-fluorescent powder, will cover the fluorescent area, and will absorb any penetrant seeping from a defect. If a flaw exists, an indication should be visible within ten minutes. If the operator is unable to determine whether fluorescence is due to an indication or incomplete washing, the parts should be degreased and again run through the entire operation.

l. TABLE OF FLUORESCENT PENETRANT DATA.

Part	Immersion	Drain	Let Stand After Washing
Cylinder	10 min.	5 min.	10 min.
Intermediate Rear Case and other Magnesium Casings	10 min.	10 min.	15 min.
*Crankcase Sections and other Forged Aluminum Parts	45 min.	15 min.	30 min.

*Heat in degreaser before immersion in penetrant.

SECTION VII

REPAIR AND REPLACEMENT

1. GENERAL.

a. The repair and replacement operations should be accomplished in accordance with instructions in this section. If it is found that the proper repairing of a part necessitates the use of special equipment not available in the overhaul shop. AAF personnel will apply to Headquarters, Air Service Command and Navy personnel will apply to Aviation Supply Office, Philadelphia, Penn., for disposition instruction.

b. If, during repair or assembly, some defect or unusual condition in a part is discovered which was not detected during inspection, the inspection report and the part should be returned to the inspector so that he may record its true condition.

2. GENERAL REPAIR PROCEDURE.

a. SCRATCHES, ROUGHNESS, CHAFING.—Using crocus cloth and gasoline, clean up light scratches, roughness, and chafing from finished surfaces of engine parts. Specific instances where this is not advisable are given in the text of this chapter.

b. NICKS, BURRS, SCORES.—Remove small nicks, burrs, and scores, and smooth slightly galled and pitted areas from finished surfaces of engine parts by light stoning. After stoning, clean the parts with crocus cloth and gasoline. Specific instances where stoning is not advisable are given in the text of this chapter.

c. PITTING, GALLING.—It is permissible to stone gear teeth in some cases to remove slight pitting or galling. Care must be exercised, however, not to stone to a degree which would result in changing the tooth form contour. Excessive stoning of the pitch diameter should be avoided in particular, as this will result in unequal tooth loading when in mesh with the mating gear. Small nicks or burrs on the tooth side faces or on the crest of the tooth may be stoned out provided the tooth form is not changed or that removal of an appreciable amount of metal is not necessary. Any gear which is severely pitted, galled, or has deep nicks or burrs, the removal of which would necessitate excessive stoning, should be discarded and replaced with a new gear.

d. THREADS.—Clean up and dress burred or mutilated threads in all parts, except in cases where it is specifically noted that this is not advisable.

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f. SINTERED BUSHINGS.—Never ream, scrape, bore, or hand burnish a sintered bushing. This type of metal is porous in nature, and provides lubrication to the shaft by means of oil seepage through the porous openings. If reaming, scraping, or hand burnishing is attempted, these operations will seal the pores and prevent proper lubrication. Broaching to size is the only recommended method. Any parts fitted with sintered bushings should never be placed in any solvent cleaning solution as these solutions are highly penetrating and will result in removing the lubricant from the pores of the metal. It is permissible to clean sintered bushings with crocus cloth and gasoline provided these materials are used sparingly to avoid filling the pores. However, upon completion of such cleaning, the bushings and the shaft should be treated with corrosion preventive mixture before assembling the parts.

g. OIL HOLES.—The use of paraffin to plug oil holes while drilling or reaming, to prevent entrance of chips into the holes and oil passages, is permissible providing the paraffin is not run into the hole in a melted condition. This procedure would block off the oil passage and make removal of the paraffin difficult. If a small ball of paraffin is rolled between the fingers and then used like putty there will be no difficulty in removing the paraffin from the hole.

h. DRILLING, REAMING.—After drilling or reaming holes, break all the sharp edges remaining around the holes and remove all burrs, using a fine stone or crocus cloth.

i. ALIGNMENT OF OIL HOLES.—To obtain alignment of oil holes in a bushing and an engine part when pressing in new bushings, draw a pencil line lengthwise on the bushing through the center of the oil hole parallel with the bore. Do the same with the bushing hole in the engine part. Install the bushing on its press-in plug, align the two pencil marks, and press in the bushing.

j. IDENTIFICATION OF PARTS.—Investigation of some part failures has revealed that they have been

caused directly by identification marks improperly placed on the parts by the operator. The incorrect method of marking parts or the marking of parts in certain areas may produce surface cracks which will progress, resulting in complete failure of the part and serious damage to the engine. This applies particularly to highly stressed parts which have been metal stamped or electrically etched. The engine manufacturer will not be responsible for any damage to an engine which may be traced to any marks placed on any steel parts of the engine by the operator either by metal stamping, center punching, or electric etching. Marks placed on certain parts by the factory are placed in definite areas where experience has indicated it will be safe to place them. Other parts are identified through the use of a special etching fluid, Zincograph, 1 and 2, and a rubber stamp. The etching fluid may be used to saturate an ordinary ink stamping pad and is used with a rubber stamp in the same manner as an ordinary ink stamp pad. After a part is etched, the surface should be treated with corrosion preventive mixture. This etching fluid should never be used for etching of steel parts to detect defects.

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2A. RESIN COATING OF INTERNAL ENGINE PARTS.

NOTE

The resin coating may be left intact, provided that the part does not require magnetic inspection and there is no flaking or peeling of the finish.

a. STRIPPING RESIN COATING.

To strip resin coating prepare the following mixture:

Ingredient	*Part by Weight*
Sodium Resinate	1.0
Sodium Metasilicate	3.0
Trisodium Phosphate	1.0
Soda Ash	2.0
Caustic Soda	4.0

Dissolve eight ounces of the mixture in each gallon of water used in a clean steel tank. Operate the solution at approximately 93°C. (200°F.). Immerse the parts in the stripping solution until the resin coating has been removed, using a soft bristle brush to facilitate removal of the coating. Rinse the parts in cold water and then in hot water to remove all traces of the alkaline stripper. Dry the parts with an air blast. Coat the part with corrosion preventive compound, Specification MIL-C-7853.

NOTE

Since the stripping solution may attack aluminum or bearing alloys, mask such surfaces before immersing the parts in the stripping solution. If masking the parts is not possible, soft grit blast the parts to remove the resin coating.

b. CLEANING PARTS.

Do not handle surfaces to be resin coated after the part has been cleaned.

1. Steel Parts with no Aluminum Details.

a. Degrease the parts in trichlorethylene, Specification MIL-T-7003.

b. Soak the parts for five minutes in a soap solution heated to 82°C.-93°C. (180°F.-200°F.).

c. Rinse the parts in water warmed to 66°C.-82°C. (150°F.-180°F.).

d. Rinse the parts in one percent (by weight) chromic acid solution at room temperature for 15-30 seconds.

e. Rinse the parts in cold water.

f. Rinse the parts in hot water.

g. Dry the parts with an air blast, and unrack.

2. Steel Parts with Aluminum Details.

a. See "a" above.

b. Cool the parts to room temperature.

c. Wipe the surfaces to be resin coated with a clean cloth wet with acetone.

d. Dry the parts with an air blast.

3. Painted Magnesium Parts.

a. Degrease the surface to be resin coated, using a clean cloth wet with acetone. (Note that vapor degreasing is not recommended, for prolonged exposure to trichlorethylene may affect the painted surface).

b. Dry the parts with an air blast.

c. APPLICATION OF RESIN COATING.

(1) Insulate surfaces not to be resin coated with masking paper and Scotch Tape.

(2) Prepare the resin mixture in accordance with the manufacturer's recommendations. (Note that the resin and thinner should be obtained from the same vendor to ensure compatability of the materials).

(3) Spray the resin coat evenly to obtain a thickness of 0.0002-0.0008 inch on machined surfaces and 0.0006-0.0010 inch on shot-peened or cast surfaces. The coating should be free of pin holes, air bubbles, runs, or sags.

NOTE

The resin material contains 0.1 percent Victoria blue dye. The operator, through experience, will be able to control the thickness of the resin film by noting the intensity of the blue color on the parts.

(4) If the spraying equipment is not available, the parts may be resin coated by the dip method. The viscosity of the material for dip coating should be governed by the vendor's instructions. Precautions should be taken to prevent the formation of beads of resin, which would tend to chip off and clog the oil system.

(5) Remove the masking materials and clean off the overspray with acetone.

(6) Allow the resin coat to air-dry for about 15 minutes prior to baking.

NOTE

Air drying avoids the possibility of the flow of resin or the formation of bubbles and pin holes in the resin film due to the rapid escape of solvent when the part is dried in a baking oven.

(7) Bake for one and one-half to two hours at the required temperature, as listed below, to polymerize the resin completely.

Parts	*Temperatures*
Carborized	127°C. (126°F.) maximum
All Other Steels	140°C. (285°F.) maximum
Aluminum and Magnesium	149°C. (300°F.) maximum

NOTE

If the part is baked properly, the blue color of the resin will be converted to a distinct green color. The resin film should be sufficiently transparent to make the metal surface beneath the film discernible.

d. BAKING TESTS.

(1) Test for Underbake.

Apply a clean cloth saturated with acetone to a selected spot on the cooled part, and rub briskly for about one minute. Softening of the resin or transfer of the dye color to the cloth indicates insufficient baking, and the part should be baked as necessary.

(2) Test for Overbake.

(a) Method I. Test a sample part that has been resin coated for brittleness by drawing a knife blade over the surface of the part and observe any inferior adhesion or tendency to flake or chip.

(b) Method II. Compare the color of coated parts with color comparison standards showing the minimum and maximum acceptable baking conditions and any overbaking condition likely to be encountered.

e. REAPPLICATION OF RESIN COATING.

(1) If a part is rejected for unsatisfactory coating prior to baking, use acetone or any other solvent to strip the coating. Reclean and recoat the part.

(2) If the part is rejected for unsatisfactory coating after baking, restrip, reclean, and recoat the part.

(3) If the resin coat is damaged by improper handling and not by loss of adhesion, reapply the coat as follows:

(a) Clean the damaged areas with acetone.
(b) Dry the parts with an air blast.
(c) Reapply the resin coating by brush or spray.
(d) Baking is not required.
(e) Air-dry for at least 15 minutes prior to handling.

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(3) PLATING ARTICULATED ROD KNUCKLE PIN BUSHINGS.

(a) It is recommended that newly installed articulated rod knuckle pin bushings be lead plated after finish boring. Refer to section VII, paragraph 48, for instructions regarding finish boring of articulated rod knuckle pin bushings.

(b) Do not attempt to lead plate used knuckle pin bushings. A used bushing may be continued to be used in the engine whether or not it was plated before original installation, if inspection of the bushing indicates that it is still in good serviceable condition.

(c) A fixture for lead plating knuckle pin bushings may be procured under Tool No. 800975. Refer to Figure 154.

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(d) This fixture consists of a base or bottom plate on which the knuckle pin end of the articulated rod is located by means of three locating pins. The bottom plate is also provided with two long studs for attaching the top plate, as well as an opening for inserting the plating solution hose plug. The articulated rod is held in place by means of a top plate placed over two studs screwed into the bottom plate. The top plate is also utilized to carry the plating anode. Two hand knobs attached to the threaded ends of the long studs are used to secure the top plate in position when the articulated rod is installed in the fixture.

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(e) Two semi-hard rubber gaskets are utilized to prevent leakage of the plating solution, one being located in a recess in the bottom plate and the other in a recess in the top plate.

(f) A wooden holding fixture, consisting of a base and two slotted uprights for supporting the articulated rod may be made locally.

(g) A leveling bottle of one quart or one liter capacity, to which a rubber hose and pinch clamp is attached, is utilized for holding the plating solution.

(h) A standard 6-volt storage battery may be used as a current supply. Connect the battery in series with a carbon pile rheostat and a standard 0-10 ampere ammeter. A voltmeter may be used in the circuit if desired, as a check on the current supply. The rod itself serves as a cathode, or negative electrode, a standard battery clip attached to the negative lead being used to make the connection to the rod. A pure lead anode or positive electrode (Tool No. 801337) is installed as shown in the sketch. Refer to Figure 154.

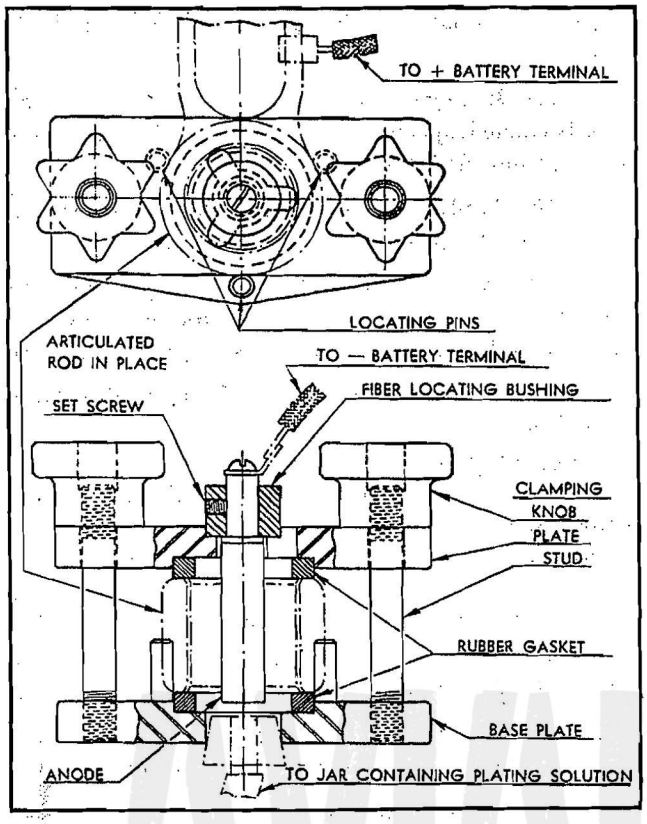

Figure 154—Fixture for Plating Articulated Rod Knuckle Pin Bushing

(i) Perform the lead plating operation at room temperature, as follows:

1. Remove all grease and oil from the surfaces to be plated by washing thoroughly in trichlorethylene, carbon tetrachloride or unleaded gasoline.

2. Rinse the knuckle pin end of the rod thoroughly in a solution of Clepo No. 64 cleaner (8 oz. to 1 gallon of water), or its equivalent soap cleaner, heated to 100 deg C (212 deg F).

3. Rinse in hot water.

4. Rinse in cold water.

5. Rinse in hot water.

6. Scrub the bearing surface with powdered pumice and water, using a soft bristle brush.

7. Rinse thoroughly in clean cold water.

CAUTION

Do not touch surface to be plated after cleaning.

8. Place articulated rod on wooden holding fixture and install plating fixture (Tool No. 800975). Place one rubber gasket on bottom plate of plating fixture and place bottom plate over the knuckle pin end of the articulated rod with the locating pins around the outside diameter. Place the other rubber gasket over end of knuckle pin bushing and install top plate over the two studs on bottom plate. Clamp rod in position with the two hand nuts. Refer to Figure 154.

9. Place plating anode (Tool No. 801337) with fibre locating bushing through the hole in the top plate, allowing the bushing to rest in the counterbore hole. Adjust the anode so that the bottom end extends through, and approximately 1/8 in. below, the knuckle pin bushing. Check to see that the lead anode is centered in the bushing hole.

10. Connect the lead plating solution bottle to the bottom of the fixture by means of the rubber hose and rubber plugs. Hold solution jar above the level of the rod, release the pinch clamp attached to the hose and allow plating solution to flow into knuckle pin bushing recess around the anode until the surface to be plated is covered. Take care that the solution does not come in contact with any part of the articulated rod other than that to be plated. Tighten the pinch clamp.

11. Attach the positive side of the electrical circuit to the lead anode and close the circuit by connecting the negative side of the circuit to the articulated rod channel flange by means of the battery clip. Plate at .5 (1/2) ampere for 8-1/4 to 13-3/4 minutes to obtain a plate thickness of .0003 in. to .0005 in. Adjust the rheostat to obtain the exact amperage specified above and time the plating operation carefully.

12. After plating, detach battery clip from rod. Lower solution bottle below level of rod, release pinch clamp and allow solution to drain back into bottle. Tighten pinch clamp on the hose.

13. Remove the anode and the locating plate from the rod. Remove the rod from the fixture.

14. Rinse rod thoroughly in hot water.

15. Blow dry with air hose, but do not turn air blast directly on bearing surface, as there may be small particles of oil or dirt in the air stream.

16. Remove all acid stains on outer diameter of rod with small felt wheel.

17. Dip rod in clean lubricating oil.

(j) Extreme care must be exercised to maintain a chemically clean bearing surface prior to plating in order to obtain an adherent, uniform plate, free from pin holes, blisters and strain. A defective plate can only be safely removed by scrubbing with pumice. If an uneven color of lead plate or a spongy deposit should be obtained, discard the lead plating solution, remove the defective lead plate and replate, using new solution.

(k) Instructions for the compounding of the lead plating solution and for the maintenance of the proper solution strength will be found in Section VII, paragraph 2 *k*.

l. ENAMEL FINISHING.

(1) BLUE-GRAY ENAMEL.

(a) This finish is used on the following parts: Crankcase front section, oil sump, oil pump, supercharger front housing, supercharger rear housing, supercharger rear housing cover and dual accessory drive housing.

(b) Complete removal of the old enamel is in many instances unnecessary if the condition of the original enamel is good except for chipped areas. This can be determined by testing the finish for adhesion to the surfaces and if it is not brittle and does not chip off, the part should be refinished as follows:

(c) Clean thoroughly, using a spray of PS-661 or VV-K 211.

(d) Sandpaper the chipped areas, using No. 340 sandpaper and use No. 320 sandpaper to smooth the remaining surfaces to obtain a good bonding surface. The sandpaper may be used either wet or dry.

(e) After the desired results are obtained, clean thoroughly with a spray of PS-661 or VV-K 211.

(f) Apply a light coat of Zinc Chromate primer to the chipped areas, being careful not to coat the machined parting surfaces.

(g) Zinc Chromate primer may be made up by mixing 1-1/2 parts of Toluol thinner Specification AN-R-T-541 to 1 part of Zinc Chromate (package material) Specification AN-TT-P-656.

(h) Place the part in a flameless oven at 106 deg C (225 deg F) and bake for 2 hours, or at 120 deg C (250 deg F) for 1-1/2 hours.

(i) Apply the first coat of Blue-Gray enamel and place the part in a flameless oven 106 deg C (225 deg F) for 2 hours or 120 deg C (250 deg F) for 1-1/2 hours.

(j) Blue-Gray enamel may be made by mixing 9 parts enamel, Specification NAF E-5 to 1 part Toluol, Specification AN-R-T-541.

(k) Apply a second coat of Blue-Gray enamel and follow the procedure described above.

(l) The enamel after being baked shall be hard enough to resist the action of gasoline at room temperature and lubricating oil at 163 deg C (325 deg F).

(m) For complete removal of the old Blue-Gray enamel on sections which have not been subjected to cleaning solutions use steel wool for an abrasive and a mixture consisting of 50 percent each acetone and Toluol Specification AN-R-T-541. The parts may be sandblasted if such equipment is available.

(2) BLACK ENAMEL.

(a) This finish is used on cylinder air deflectors, intake pipes, push rod housings and rocker box covers.

(b) As previously described above, all parts must be thoroughly cleaned before painting.

(c) Apply a light coat of Zinc Chromate primer and bake at 120 deg C (250 deg F) for 1-1/2 hours.

(d) Apply the first coat of Black Baking Enamel, place in a flameless oven at 120 deg C (250 deg F) and bake for 1-1/2 hours.

(e) Apply a second coat of Black Enamel and proceed as above.

(f) Black Baking Enamel may be made by mixing 9 parts enamel, Specification NAF E-6 to 1 part Toluol Specification AN-R-T-541.

(g) The enamel after being baked shall be hard enough to resist the action of gasoline at room temperature and lubricating oil at 163 deg C (325 deg F).

(3) FINISHING CYLINDERS.

(a) Before painting a cylinder, the surface must be carefully prepared.

(b) The condition of the surface governs to a great extent the preparations necessary to obtain a satisfactory finish. The appearance of the completed work is also dependent upon the equipment available and the degree of finish required by the operator concerned.

(c) Sandblasting effectively removes the old enamel, rusted or corroded areas, and roughens the

surface of the metal to provide a good bonding surface for the enamel.

(d) Some engines have the cylinder metalized as corrosion prevention and are enameled over the metalizing. The old paint may be removed from cylinders that have been metalized and then painted without disturbing the metalized coating, if the sandblasting operation is carefully controlled.

(e) If sandblasting equipment is not available, burned or chipped enamel may be cleaned and smoothed with sandpaper. The cylinder should be free from grease or oil prior to re-enameling.

(f) After the surfaces have been prepared and cleaned the cylinder should be made ready for spraying as follows:

1. Install dummy plates on the exhaust flanges and on the intake flanges.

2. Install plugs in both push rod housing connections and cover the outside surfaces with masking tape.

3. Install dummy plugs in the spark plug inserts, rocker bolt holes and cylinder mounting flange holes. An old set of spark plugs with washers may be used to protect the threads and face of the spark plug insert. Plugs for rocker bolt and cylinder mounting flange holes should be provided that will protect the spherical seats at these locations.

4. Insert screws in cylinder head and intercylinder baffle attaching bushings.

5. Install a sleeve on the outer surface of the cylinder barrel skirt below the mounting flange to protect this surface as well as the underside of the flange.

6. Install covers on the rocker boxes. Figure 155 shows a cylinder prepared for enameling.

(g) Apply a priming coat of AN-TT-E-501. Remove all plugs. Place the cylinder in an oven heated 250 deg C (400 deg F) and bake for 2-1/2 hours. Remove the cylinder and allow it to cool.

(h) Reinstall the plugs, apply a coat of Hilo No. 934 black finishing enamel, remove the plugs, place the cylinder in an oven and bake for 2-1/2 hours at 205 deg C (400 deg F). Remove the cylinder and allow it to cool.

(i) The finish may be improved by applying two coats of enamel.

3. STUD REPLACEMENT.

a. REMOVING STUDS.

(1) If the stud requiring replacement is not broken, it may be removed by using the applicable stud remover.

(2) If the stud requiring replacement is broken, it will be necessary to drill the stud, using drills of successively larger diameter, and then remove the remaining shell, using a removing tool.

(3) If the fracture of the broken stud is jagged, true up the end of the stud so that the starting drill may be accurately centered.

(4) If the stud is broken below the mounting surface, true up the end of the stud, using a double-fluted end cutter slightly smaller in diameter than the root diameter of the stud.

(5) Use a suitable drill jig with a drill bushing when performing this operation, centering the drill bushing over the stud hole and clamping the jig in this position to avoid damaging the stud hole threads.

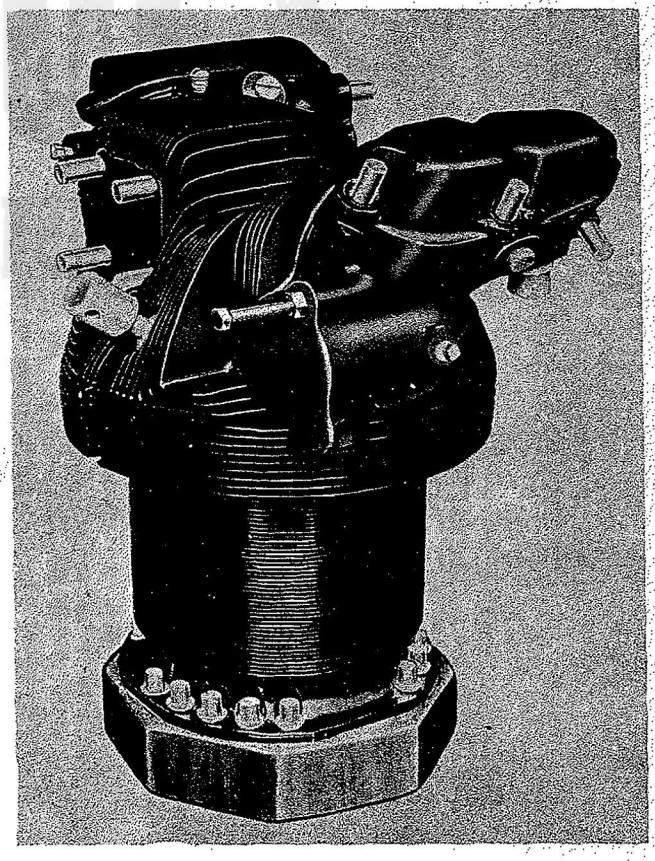

Figure 155—Method of Masking a Cylinder for Enameling

(6) Drill the broken studs, using the drill jig clamped centrally over the stud hole. If the stud hole is tapped blind, take care to insure that the drill does not bottom in the stud hole.

(7) Insert a square stud removing tool of the proper size into the drilled hole in the stud and screw out the remaining shell.

b. INSTALLING STUDS.

(1) Clean up the stud hole threads, using the proper size tap.

CAUTION

Carefully inspect all taps before using in an engine part, since rough edges or burrs on the tap may cause the tap to cut an oversize hole. All taps should be tried in a test block made of the same material as that in which the tap is to be used. The tap being tested should not free itself enough to shake in the tapped hole. If such shaking is possible, that is an indication that the tap is not free of burrs. Remove burrs if necessary.

(2) Select the proper size stud. If the stud is to be installed in a blind hole, coat the threads with engine lubricating oil. If the stud is to be installed in a hole that has been drilled through, apply a thin coating of thread compound, Specification AN-C-53, to the bottom threads in the stud hole, and lightly coat all except the first or leading thread on the new stud with thread compound which conforms to Specification AN-9516.

(3) Screw the stud into the stud hole, using a stud driver and torque wrench. Refer to the Table of Limits for the proper torque to be used in driving studs. If, after applying the proper torque, the nut end of the stud is not at the proper height above the mounting surface, remove the stud. Retap the stud hole slightly deeper, using the standard size tap and reinstall the standard size stud if the stud height is too great. Retap the stud hole, using an oversize tap and install a new stud having the corresponding oversize if the stud height is too low.

(4) Follow this procedure for removing and installing studs of various sizes.

4. ANTIFRICTION BEARINGS.

a. No repair should ever be attempted on an antifriction bearing except stoning the outside diameter of the outer race or the inside diameter of the inner race or the ends of either race to remove slight nicks or scoring. Care should be exercised to insure that the limits and proper fits of the bearing are not exceeded. If inspection of antifriction bearing indicates the presence of any damage other than scratching or scoring of these surfaces, replace the bearing with a new part.

b. When antifriction bearings are received from the manufacturer, do not break the box seal or unpack each bearing in order to check the packing slip. Bearing numbers are printed plainly on the outside of the box. Above all, do not break the box seals before delivering the bearings to the mechanic who will install them. Store bearings in a cool, dry place until ready for use.

c. Be sure that every box is sealed. In case the seal has been broken, remove the top lid and see if the waxed paper in which the bearing is wrapped is broken or shows signs of having been opened. Determine if the seal was broken due to rough handling in transit or in unpacking. If it appears that the seal was broken due to carelessness, reseal with a piece of gummed tape, if it is certain no dust or dirt could possibly have reached the bearing. If the bearing box is badly mutilated, and the waxed paper punctured or torn, the bearing should not be put into service until it has been carefully inspected to determine whether dirt could have gotten into the grease in which the bearing is packed.

d. It is not necessary to wash the lubricant from new bearings providing the package has not been opened. The bearing manufacturer uses a high grade non-acid lubricant free from all chemicals and impurities that might cause corrosion. In every case where the package has been opened and dirt and dust has had an opportunity of lodging in the bearing it will be necessary to clean the bearing as described in Section V, paragraph 7 *l*.

e. The first rule in handling bearings is clean hands and clean tools. Keep plenty of clean rags available and use them often. Do not use waste as the lint and short strands adhere readily to oiled surfaces. Keep hands wiped dry.

f. A very important protective measure is to keep the assembly benches where antifriction bearings are handled as clean as possible. It is good practice to place a clean sheet of paper on the bench on which the bearings can be placed just prior to their installation in the engine. This eliminates the possibility of

dirt and metal chips from the bench sticking to the oil surface and being carried into the engine.

5. CRANKCASE FRONT SECTION.

a. Refer to paragraphs 2 and 3 of this section for general repair procedure and stud replacement.

6. PROPELLER GOVERNOR DRIVE.

a. If replacement of the governor drive gear shaft bushing is found to be necessary, remove the used bushing and install a new bushing, using the set of tools (Tool No. 800998) designed for this purpose. Instructions for performing this replacement are as follows:

(1) Pull out the worn bushing from the crankcase, using puller (Tool No. 800995-1) and nut (Tool No. 800995-3).

(2) Pull in the new bushing with the oil hole and flat located in position, using puller (Tool No. 800995-1) and nut (Tool No. 800995-3).

(3) Ream the bushing hole, using fixture (Tool No. 83662) and reamer (Tool No. 83663). Check the reamed hole with gage (Tool No. 83666).

(4) Square up and clamp the crankcase against a standard angle plate in a drill press. Set the cutter in bar (Tool No. 83664) so the angular cutting edge will clear the bushing when facing the bushing flange. Face the flange and check with gage (Tool No. 800996). Reset the cutter so that the facing edge will clear the flange when chamfering. Chamfer the hole to 1.20 ± .010 in. at an angle of 45 deg.

7. THRUST BEARING—.666 (3:2) REDUCTION GEAR.

a. For instructions regarding the repair and handling of the thrust bearing, refer to paragraph 4, above.

8. STATIONARY REDUCTION GEAR—.666 (3:2) REDUCTION GEAR.

a. Stoning the faces of the stationary reduction gear teeth is not permitted under any circumstances.

b. If the inside diameter of the stationary reduction gear is worn by the thrust bearing spacer oil seal rings, grind the inside diameter of the gear oversize. To do this, set up the gear in an internal grinding machine, or in a lathe with a tool post grinder, and grind the bore to either .005 in. or .010 in. oversize diameter, as required. After grinding, check to make sure that the inside diameter of the gear is square with the mounting flange and concentric with the thrust bearing outer race pilot, using a dial indicator. Break sharp edges at the ends of the bore to 1/64 in. radius after grinding.

NOTE

Oversize thrust bearing spacer oil seal rings must be used in every case with a stationary reduction gear which has been ground oversize on the inside diameter. Use oversize rings corresponding to the gear inside diameter oversize.

9. CRANKCASE FRONT SECTION FLANGE AND SPACER—.666 (3:2) REDUCTION GEAR.

a. If the inside diameter of the crankcase front section flange is worn by the thrust nut oil seal rings, grind the inside diameter of the flange oversize. To do this, set up the flange in an internal grinding machine, or in a lathe with a tool post grinder, and clean up the bore by grinding as required. After grinding, check to insure that the inside diameter of the flange is square with the mounting flange and concentric with the front section bore pilot, using a dial indicator. Break sharp edges at the end of the bore to 1/64 in. radius after grinding.

NOTE

Oversize thrust nut oil seal rings must be used in every case with a front section flange which has been ground oversize on the inside diameter. Use oversize rings corresponding to the flange inside diameter oversize. These rings may be procured in .005 in., .010 in., .015 in., and .020 in. oversize on the outside diameter.

10. PROPELLER SHAFT FRONT BUSHING—.666 (3:2) REDUCTION GEAR.

a. If replacement of the propeller shaft front bushing is found to be necessary, perform this replacement in accordance with the following instructions: Clamp the propeller shaft rear end to a lathe face plate. Screw the steady rest bushing (Tool No. 83995) on the propeller hub nut threads on the propeller shaft, and support the front end of the shaft by means of a steady rest over the bushing. Indicate the surface forward of the propeller shaft splines, and the shoulder behind the thrust bearing journal, to run true within .002 in. full indicator reading. Bore out

the flange of the bushing to a diameter of 2-13/32 in. and to a depth of 1/4 in. Bore out the bushing to a diameter of 2.150 in., leaving a shell .005 in. thick remaining in the shaft. Remove the shaft from the lathe and pick out the bushing flange and the remaining shell. Remove the washer.

CAUTION

Take care to insure that the propeller shaft sleeve is not damaged during this operation.

b. Remove sharp edges and smooth the bushing bore in the shaft. Check the inside diameter of the bushing bore and the outside diameter of the new bushing to insure that the proper tight fit will be obtained. Refer to the Table of Limits in Section XII.

c. Heat the propeller shaft in an oil bath at a temperature of 205 deg C (400 deg F) for twenty minutes. At the same time, install the new bushing on its pressing-in plug (Tool No. 84308), and chill these parts in a solution of denatured alcohol and dry ice for twenty minutes.

d. Place the propeller shaft, rear end down, on a fiber pad on an arbor press table to prevent scratching the shaft when pressing in the bushing. Install a new propeller shaft front bushing washer in position in the shaft. Press the new front bushing into the shaft, using the plug (Tool No. 84308) until the bushing flange is bottomed on the washer. Remove the plug.

e. It is necessary to finish bore the propeller shaft bushings after installation in the shaft. This operation is accomplished in boring fixture (Tool No. 84617). Locating bushings (Tools No. 84618 and 84619) are used in this fixture in order to centralize the propeller shaft in the fixture. Install adapter (Tool No. 84621) and bushing (Tool No. 84618-1) in position in the fixture. Lock the bushing in position on the adapter, using the three cap screws. Install bushing (Tool No. 84619) in position in the fixture and secure with the six cap screws. Install the propeller shaft, front end down, in the locating bushings in the fixture, and clamp by means of the clamping plate (Tool No. 84618-2), securing the clamping plate using the three nuts. Turn the bronze hand wheel to lock the propeller shaft in position. Bend down the hinged cover of the fixture (Tool No. 84617-3), and turn the two wing nuts to lock the cover in position.

f. Boring bar (Tool No. 802052-1) and tool bit (Tool No. 802052-2) are used in finish boring the propeller shaft front bushing. Insert the tool bit in the boring bar. Cutter set gage (Tool No. 801101-1) is used in setting the tool bit. Attach the gage to the anvil of a micrometer. Determine the proper setting of the tool bit as follows: Measure and record the diameter of the crankshaft at the propeller shaft front bushing journal. Refer to the applicable Table of Limits for the proper clearance between the crankshaft and the propeller shaft front bushing, and record the minimum clearance. To one-half of the crankshaft diameter, add one-half of the desired clearance. Add to this the gage constant, which is stamped on the gage. The total of these three items is the dimension to which the tool bit should be set, measured to the cutting edge of the tool. Lock the tool bit in the boring bar by means of the set screw.

EXAMPLE

Diameter of Shaft—
1.978 in., 1/2 equals .989 in.
Desired Clearance—
0.0025 in., 1/2 equals .0013 in.
Gage Constant ..... .900 in.
Set Cutter to ..... 1.8903 in.

CAUTION

When setting the tool bit, do not drag the micrometer spindle heavily over the cutting edge of the tool, since this may damage the micrometer, dull the tool, or result in an improper setting. Use a light touch to insure that the finished bore will be of the correct diameter. Move the micrometer spindle away from the cutting edges of the tool, from the clearance angle toward the cutting tooth. Check the setting of the tool bit after locking.

g. Install slip bushing (Tool No. 84626) in the cover of the fixture, and install the boring bar in the slip bushing, resting the bar on a supporting pin. Place the fixture on a drill press bed plate. Install chuck (Tool No. 83921) in the drill press spindle, and locate the drill press spindle directly over the boring bar. Lower the spindle, attach the chuck to the boring bar, remove the supporting pin, and bore the bushing to size. Remove the propeller shaft from the fixture.

11. PROPELLER SHAFT REAR BUSHING—.666 (3:2) REDUCTION GEAR.

a. If replacement of the propeller shaft rear bushing is found to be necessary, perform the replacement

in accordance with the following instructions: Clamp the propeller shaft horizontally in a vise or other suitable holding fixture so that the propeller shaft rear bushing pin is pointed directly upward. Use soft metal strips over the jaws of the vise to avoid damaging the propeller shaft. Mark the center of the head of the pin, using a center punch. Using a standard 9/32 in. diameter drill, drill .115 in. deep to remove the head of the pin. Take care to drill no deeper than is necessary to remove the pin head so that no metal will be removed from the propeller shaft. Drive out the pin.

b. Install the propeller shaft in boring fixture (Tool No. 84617), used in connection with locating bushings (Tools No. 84618 and 84619) and adapter (Tool No. 84621), in the same manner as previously described for finish boring the propeller shaft front bushing. Bore out the propeller shaft rear bushing, using boring bar (Tool No. 802052-1) and tool bit (Tool No. 801101-2). Install the slip bushing (Tool No. 84626) on the boring bar. Set the stop collar on the bar to limit the travel of the cutter and so avoid damaging the propeller shaft sleeve. Set the tool bit to the small diameter of the setting gage (Tool No. 801101-1), and lock with the set screw. Install the bar in the fixture, permitting it to rest on a supporting pin. Install chuck (Tool No. 83921) in the drill press spindle, lower the spindle and attach the chuck to the boring bar, remove the supporting pin, and bore out the bushing. Make a second cut in the same manner after resetting the tool bit to the large diameter of the gage (Tool No. 801101-1). Remove the shaft from the fixture.

c. Pick out the remaining shell of the bushing. Remove sharp edges and smooth the bushing bore in the shaft. Check the inside diameter of the bushing bore and the outside diameter of the new bushing to insure that the proper tight fit will be obtained. Refer to the Table of Limits in Section XII.

d. Heat the propeller shaft in an oil bath at a temperature of 205 deg C (400 deg F) for twenty minutes. Install the new bushing on its pressing-in plug (Tool No. 801916-3) after drawing pencil lines lengthwise on the bushing and bushing bore in the shaft through the oil holes. Chill the bushing in solution of denatured alcohol and dry ice for twenty minutes.

e. Hold the propeller shaft, front end down, on a fiber pad on an arbor press table. Press the new rear bushing into the shaft, using the plug (Tool No. 801916-3) until the bushing is bottomed on the rear end of the propeller shaft sleeve. Make sure that the pencil marks on the bushing and shaft are aligned during this operation to insure proper alignment of the oil holes in the bushing and shaft. Remove the plug.

f. Drill a 15/64 in. diameter hole through one wall of the new bushing at the lock pin hole in the shaft, using a standard 15/64 in. diameter drill. Ream this hole to a diameter of .2485 to .2495 in. and check using plug gage (Tool No. 83933). Drive in a new lock pin.

g. Finish bore the propeller shaft rear bushing in the same manner as previously described for the front bushing, except use tool bit (Tool No. 801101-3), and gage (Tool No. 801101-1).

12. PROPELLER SHAFT PINION BUSHINGS—.666 (3:2) REDUCTION GEAR.

a. If replacement of any of the reduction gear pinion bushings is found to be necessary, perform this replacement in accordance with the following instructions: Clamp the propeller shaft horizontally in a vise, using soft metal strips over the jaws of the vise, so that the pinion arm in which the bushing requiring replacement is located is pointing directly upward. Mark the center of the head of the lock pin, using a center punch. Using a standard 9/32 in. drill, drill 3/32 in. deep to remove the head of the pin. It may be necessary to drill, using a 5/16 in. diameter drill, to remove peened-over metal from the head of the pin before picking out the head of the pin. Drive out the pin.

b. Install the propeller shaft in boring fixture (Tool No. 84617), used in connection with locating bushings (Tools No. 84618 and 84619) and adapter (Tool No. 84621) in the same manner as previously described for finish boring the propeller shaft front and rear bushings. Before locking the propeller shaft in position by tightening the bronze hand wheel on the fixture, install aligning plug (Tool No. 84618-3) in the fixture to align the pinion bushing in the propeller shaft with the boring bar pilot bushings in the fixture. Tighten the hand wheel to lock the propeller shaft in this position. Remove the aligning plug.

c. Bore out the pinion bushing, using boring bar, tool bit (Tool No. 84621-6), and chuck (Tool No. 83921). Bore out the bushing in two cuts, setting the tool bit for each cut with the small and large diameters, respectively, of setting gage (Tool No. 84621-5). Remove the shaft from the fixture.

d. Pick out the remaining shell of the bushing. Break sharp edges and smooth the bushing bore in the shaft. Check the inside diameter of the bushing bore and the outside diameter of the new bushing to insure that the proper tight fit will be obtained. Refer to the Table of Limits in Section XII.

e. Install the bushing on the press-in bar, Tool No. 801914-12. Place the thrust collar on the press-in bar on top of the bushing and assemble to the pressure plate, Tool No. 801914-1. Locate the aligning pin with the locking pin hole in the bushing. This will insure proper positioning of the bushing in regard to oil holes and the locking pin hole in the trunnion carrier extension. Immerge the bushing and the assembly in a solution of dry ice and alcohol for twenty minutes. Heat the propeller shaft to 400°F. Place the propeller shaft on an arbor press with the extension in a downward position. Place the rest plate, Tool No. 801914-11, under the trunnion carrier extension. Place the pressure plate over the trunnion carrier extension so that two locating pins straddle the pinion arm and press the bushing into place. Remove the bushing installing tool and drive in a new lock pin and peen metal from the propeller shaft over the edge of the pin head using a peening punch.

f. Finish bore the pinion bushing in the same manner as previously described from the propeller shaft front and rear bushings, except using tool bit, Tool No. 84621-6.

g. The complete set of tools for replacing the propeller shaft front and rear bushings and pinion bushings in the .666, 3:2 reduction gear ratio propeller shafts may be procured under Tool No. 800526.

b. The complete set of tools for replacing propeller shaft front and rear bushings and pinion bushings in .666 (3:2) reduction gear ratio propeller shafts may be procured under Tool No. 800526.

13. PROPELLER SHAFT AND PINIONS—.666 (3:2) REDUCTION GEAR.

a. Do not stone the faces of pinion gear teeth under any condition. In some cases, pinions which have slightly pitted or galled gear teeth may be repaired by lapping and polishing the teeth. If one or more pinions require lapping, the complete set of pinions should be lapped. Lapping of pinion gear teeth should not be attempted by operators, since the required tooth form of these gears cannot be obtained without special machines and equipment. If replacement of one or more pinions is found to be necessary, it is recommended that the complete set of pinions be replaced with new parts. If this is not done, and a single new pinion is installed, the new pinion will be excessively loaded and failure of that pinion and its bushing may result. Apply to Headquarters, Air Service Command, for disposition instructions regarding these parts.

14. THRUST NUT—.666 (3:2) REDUCTION GEAR.

a. Grind the front and rear faces of the thrust nut if necessary to removed galled areas. Do not remove more than .005 in. of metal from either face, since grinding deeper than that may remove the carburizing from these surfaces. Thrust nuts which have been ground should be identified so that the maximum amount of regrind will not be exceeded at subsequent overhauls.

15. PROPELLER SHAFT FRONT BUSHING—.5625 (16:9) REDUCTION GEAR AND DIRECT DRIVE.

a. If replacement of the .5625 (16:9) ratio or direct drive propeller shaft front bushing is found to be necessary, this should be accomplished in the same manner as in .666 (3:2) reduction geared engines. The same tools are used, with the exception of fixture (Tool No. 800272), locating bushing (Tool No. 84627), and adapter (Tool No. 84628). Fixture (Tool No. 800272) is used for clamping the .5625 ratio or direct drive propeller shaft to a lathe face plate when boring out the old front bushing. Locating bushing (Tool No. 84627) and adapter (Tool No. 84628) are used for clamping the .5625 ratio propeller shaft in the boring fixture in place of the corresponding parts (Tools No. 84618 and 84621) for the .666 ratio shaft.

16. PROPELLER SHAFT REAR BUSHING—.5625 (16:9) REDUCTION GEAR AND DIRECT DRIVE.

a. If replacement of the propeller shaft rear bushing is found to be necessary, perform this replacement in accordance with the following instructions. Install drill jig (Tool No. 800182) on the propeller shaft rear flange so that the drill jig bushing hole is located directly over the propeller shaft rear bushing pin. Clamp the jig in this position. Bolt the V-block (Tool No. 84632) in the No. 1 position on holding fixture (Tool No. 84631). Clamp the propeller shaft to the holding fixture and line up the drill bushing hole in the drill jig under a drill press spindle. Drill out the lock pin, using drill (Tool No. 800186) and

drill bushing (Tool No. 800183-1), by drilling to a depth of 1-29/32 in., measured from the top of the drill bushing.

b. Install the propeller shaft in boring fixture (Tool No. 84617), used in connection with locating bushings (Tools No. 84619 and 84627) and adapter (Tool No. 84628). Bore out the propeller shaft rear bushing in the same manner as in .666 (3:2) reduction geared engines.

c. Install the new rear bushing in the propeller shaft in the same manner and using the same tools as in the .666 (3:2) reduction geared engines.

d. Reinstall the propeller shaft in the holding fixture (Tool No. 84631), in order to install a new rear bushing pin. Clamp drill jig (Tool No. 800182) on the propeller shaft rear flange so that the drill jig bushing hole is located over an undrilled portion of the flange. Do not use the same pin hole in the shaft as was used for pinning the bushing which was removed. Using drill (Tool No. 800186) and bushing (Tool No. 800183-1), drill a hole in the bushing and shaft to a depth of 1-29/32 in., measured from the top of the drill bushing. Ream this hole, using reamer (Tool No. 800154) and bushing (Tool No. 800183-2). Check the hole diameter, using plug gage (Tool No. 800194). Press in the new pin, using driver (Tool No. 800183-4) and bushing (Tool No. 800183-3), until the shoulder on the driver rests on the top of the bushing.

e. Reinstall the propeller shaft in the boring fixture (Tool No. 84617), and finish bore the new rear bushing in the same manner and using the same tools as in .666 (3:2) reduction geared engines. In addition, bore a taper in the rear end of the bushing, after finish boring to size, using boring bar (Tool No. 802052-1), stop collar (Tool No. 802052-3), and tool bit (Tool No. 800187). Use gage (Tool No. 801101-1) in connection with a micrometer to set the tool bit. Set the tool bit to a micrometer reading of 2.464 in. in order to bore to a diameter of 2.628 in., measured in the propeller shaft rear bushing at the base of the 30 deg chamfer. Set the stop collar on the boring bar so that the top of the tool bit is aligned with the base of the original 30 deg chamfer. Bore the taper and remove the propeller shaft from the fixture.

f. The complete set of tools for replacing propeller shaft front and rear bushings in .5625 (16:9) reduction gear ratio propeller shafts may be procured under Tools No. 800526 and 801704. The tools included in the set of tools (Tool No. 800526) are necessary for replacing propeller shaft bushings in both .666 and .5625 reduction geared engines, and the additional tools required for .5625 reduction geared engines are included in the set of tools (Tool No. 801704).

17. PROPELLER SHAFT AND PINIONS—.5625 (16:9) REDUCTION GEAR.

a. Individual pinion bushings may be replaced with new bushings instead of replacement of complete sets. Bushings that are slightly scored and scratched may be reclaimed by lead indium plating if the bushing is otherwise serviceable and the clearance between the bushing and carrier trunnion is within specified limits. Do not attempt to plate any bushings that are excessively worn or out-of-round. Bushings that are free from scores or scratches if the clearances between the trunnion and the bushing, and the pinion and the bushing are within specified limits, can be reused without regarding extent of wear of the lead indium plating. Reduction gear pinions can also be replaced individually provided they are inspected as follows and found to be serviceable:

(1) Magnaflux.

(2) Inspect for scored or pitted teeth.

(3) Inspect for proper clearance between the outside diameter of the bushing and inside diameter of the gear.

(4) Check with gear vernier to determine that the teeth are not worn at the pitch circle.

CAUTION

Do not stone pinion gear teeth under any condition.

18. STATIONARY REDUCTION GEAR—.5625 (16:9) REDUCTION GEAR.

a. Stoning the faces of the reduction gear teeth is not permitted under any circumstances.

19. STATIONARY REDUCTION GEAR SUPPORT—.5625 (16:9) REDUCTION GEAR AND DIRECT DRIVE.

a. If the inside diameter of the stationary reduction gear support is worn by the thrust bearing spacer oil seal rings, grind the inside diameter of the support oversize in the same manner as previously described for the stationary reduction gear in .666 (3:2) reduction geared engines in paragraph 8. of this section.

20. THRUST BEARING—.5625 (16:9) REDUCTION GEAR AND DIRECT DRIVE.

a. For instructions regarding the repair and handling of the thrust bearing, refer to paragraph 4. of this section.

21. CRANKCASE FRONT SECTION FLANGE AND SPACER—.5625 (16:9) REDUCTION GEAR AND DIRECT DRIVE.

a. If grinding of the inside diameter of the crankcase front section flange is found to be necessary, do this in the same manner as previously described for .666 (3:2) reduction geared engines.

22. THRUST NUT—.5625 (16:9) REDUCTION GEAR AND DIRECT DRIVE.

a. Repair the thrust nut, if necessary, in the same manner as that described for .666 (3:2) reduction geared engines. (See paragraph 13. of this section.)

23. THRUST BEARING, PROPELLER SHAFT AND TORQUE INDICATOR PARTS—.666 (3:2) AND .5625 (16:9) REDUCTION GEARED ENGINES HAVING A TORQUE INDICATOR.

a. For the repair of all parts in the torque indicator crankcase front section, except the working parts of the torque indicator itself, refer to the foregoing text.

24. REDUCTION DRIVING GEAR.

a. Stoning the faces of the internal teeth on the reduction driving gear is not permitted under any circumstances.

25. VALVE TAPPETS AND VALVE TAPPET GUIDES.

a. Valve tappets and guides which are scored or scratched to such an extent that they may not be smoothed up by light polishing should be replaced with new parts. It is essential that a smooth finish be obtained on the outside diameter of the tappets and the inside diameter of the guides. For polishing, use Aloxite No. 320 polishing cloth, or its equivalent, and H 41 fine grade finishing compound, or its equivalent. Best results may be obtained by the use of worn polishing cloth. Do not stone the outside diameter of valve tappets or the inside diameter of tappet guides, and do not use crocus cloth and gasoline for polishing these surfaces.

b. Tools to be used in polishing valve tappets and guides may be made up by the operator, to be used in a small, high speed bench lathe. For polishing tappets, a draw bar or similar device for holding the tappet in the lathe is recommended. Make up a hand polishing tool consisting of a split block, hinged on one side at the split, and provided with two handles, one in each half of the block, on the side opposite from the hinge. There should be a semi-circular groove in each half of the block, forming a cylindrical hole slightly larger in diameter than the tappet when the halves of the block are brought together. Line the hole in the block with polishing cloth, apply a small quantity of finishing compound to the tappet, and polish. For polishing tappet guides, make up a hollow polishing plug, slightly smaller in diameter than the inside diameter of the tappet guide, provided with a slot in one side approximately 4 in. long. Insert a strip of polishing cloth in the slot, and wind once around the tool in the direction opposite from that of lathe rotation. Mount the polishing tool in the lathe chuck, apply a small quantity of finishing compound to the tappet guide, and polish. Refer to Figure 156.

c. Check the outside diameter of the tappet and the inside diameter of the tappet guide after polishing, using a micrometer and plug gage. Instructions covering the inspection of these parts are included in Section VI, paragraph 3 *c* and *d*.

26. CRANKCASE FRONT MAIN SECTION.

a. If retapping of the cylinder hold-down cap screw hole threads is found to be necessary, use for this purpose the tapping fixture (Tool No. 83654), tap holder (Tool No. 83653), and standard size tap (Tool No. 800214).

b. Clean up the threads with the standard size tap

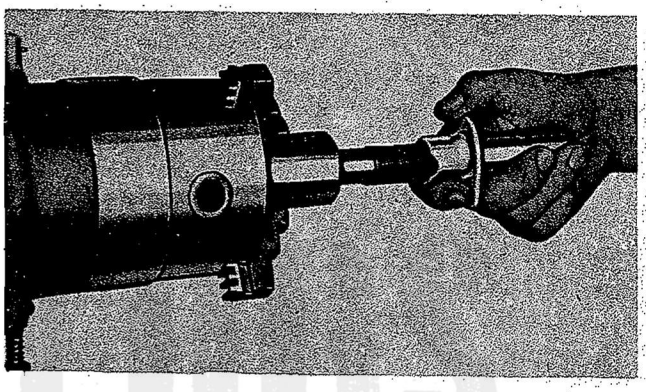

Figure 156—Polishing Tappet Guide Inside Diameter

and try a standard size cap screw in the hole. If a snug fit is obtained, no oversize will be needed. However, in cases where threads are mutilated or a standard size cap screw is loose, retap the hole oversize, using tap (Tool No. 800127) for a .007 in. oversize hole and tap (Tool No. 800128) for a .012 in. oversize hole. Use these taps to clean up the threads when either a .007 in. or .012 in. oversize cap screw is to be used.

c. For checking the size of the crankcase cap screw holes the following gages are supplied:

standard size	Tool No. 800130
.007 in. oversize	Tool No. 800131
.012 in. oversize	Tool No. 800132

d. If the threads in the cylinder hold-down cap screw holes are too badly mutilated to be reconditioned by tapping, discard the crankcase. In such cases, it will be necessary to replace both front and rear halves of the crankcase main section with new parts, since these parts are matched and are not supplied separately.

e. If the inside diameter of the crankshaft front

main bearing ring is worn by the reduction driving gear spacer oil seal rings, remove the bearing ring and grind the inside diameter oversize. To do this, set up the bearing ring in an internal grinding machine or in a lathe with a tool post grinder, and grind the bore to either .005 in. or .010 in. oversize diameter, as required. After grinding, check to make sure that the inside diameter is concentric with the outside diameter of the bearing ring. Break sharp edges at the ends of the bore to 1/64 in. after grinding.

NOTE

Oversize reduction driving gear spacer oil seal rings must be used in every case with a bearing ring which has been ground oversize on the inside diameter. Use oversize rings corresponding to the bearing ring inside diameter oversize.

f. If the front main bearing ring was removed for reconditioning, reinstall the bearing ring in the crankcase at this time. Insure that the cap screw holes in the bearing ring are exactly aligned with the drilled holes in the crankcase. It may be necessary to press the bearing ring into place in the crankcase if a tight fit is encountered between these parts. Refer to Table of Limits in Section XII for the proper fit at this location.

g. If replacement of the cam bearing ring is found to be necessary, do this in accordance with the following instructions: Use puller (Tool No. 84535) to remove the old cam bearing ring. Place the crankcase front main section on a bench so that the cam bearing ring is up. Install the puller over the bearing ring, lining up the hole in the puller ring with the locating dowel pin in the main section. Tighten the three screws into the drilled holes in the circumference of the cam bearing ring. Remove the bearing by tightening evenly the three puller screws in the puller ring against the flange of the crankcase front main section.

h. Clean up the outside diameter of the cam bearing ring support on the crankcase front main section. Measure the outside diameter of the support and the inside diameter of the cam bearing ring to insure that the proper fit is obtained. Refer to the Table of Limits in Section XII.

i. Heat the new cam bearing ring in a hot oil bath at a temperature of 149° C (300° F) for fifteen minutes. Coat the cam bearing ring support on the crankcase section with engine oil. Place the installing tool (Tool No. 800993) on the support, locating the 5/16 in. diameter hole in the tool over the dowel pin in the crankcase section. Hold the cam bearing ring, using asbestos gloves, and place over the installing tool, engaging the bearing splines correctly with the splines in the outside diameter of the tool. Press the bearing ring down so that the flange bears tightly against the crankcase. Check bottoming of the bearing ring on the crankcase by attempting to insert a .0015 in. feeler gage between these parts. Remove the installing tool after the bearing ring has cooled.

27. CRANKCASE REAR MAIN SECTION.

a. If retapping of the cylinder hold-down cap screw hole threads is found to be necessary, do this in accordance with instructions in paragraph 26 of this section.

28. SUPERCHARGER FRONT HOUSING.

a. For honing the impeller shaft front support in the supercharger front housing, clamp housing on adapter (Tool No. 801530), using fixture (Tool No. 84294). Hold hone (Tool No. 802116) in a drill press spindle and install honing stones (Tool No. 802118). If necessary, the support may be ground to either .005 or .010 in. oversize and suitable rings obtained. For honing a standard size support, adjust hone to obtain a diameter of 2.192 to 2.193 in. When an oversize support is desired, set the assembly accordingly.

b. Run the spindle at approximately 50 rpm, moving the hone up and down in the support. Hone only long enough to obtain a smooth surface, using kerosene, or its equivalent, as a lubricant. For a support with a standard inside diameter, check the finished hole with gage (Tool No. 801202). For an oversize support having a 2.197 to 2.198 in. inside diameter, check the finished hole with gage (Tool No. 801474). For an oversize support having a 2.202 to 2.203 in. inside diameter, check the finished hole with gage (Tool No. 801488).

29. ENGINE MOUNTING LUGS.

a. Where excessive wear of the engine mounting lug hole to a maximum of 31/64 inch inside diameter is indicated, the engine mounting lug hole will be reworked for installation of a locally manufactured steel flange bushing.

b. Using drill (Tool No. 84758), drill all mounting lug holes to a diameter of 41/64 in. Ream all holes to a diameter of .655-.656 in., using reamer (Tool No. 84759), and check the diameter of the holes, using

gage (Tool No. 84880). Chamfer 45° to .750 in. and spotface to 1.313 in. diameter on the propeller end of the hole.

c. Press the proper bushings in all mounting lug holes, using plug and collar (Tool No. 84881). The complete set of tools for performing this operation is supplied under Tool No. 84882.

d. If bushings have already been installed in the mounting lugs and are worn, drill out the bushing, check the inner diameter of the mounting lug hole, drill to proper size, if necessary, and install new bushing as previously described.

e. The engine mounting bolt bushings are not intended to correct any error in the mounting circle diameter caused by accident or other abnormal conditions. They are only intended to correct wear in the 15/32 diameter mounting lug holes.

30. SUPERCHARGER REAR HOUSING.

a. If replacement of the impeller drive gear front bushing is found to be necessary, do this, using the following tools: fixture (Tool No. 84854), plug and collar (Tool No. 83875), jig (Tool No. 802697), drills (Tools No. 801550, 801551, and 83802), reamer (Tool No. 801552), adapter (Tool No. 801503), line reamer (Tool No. 83051), and plug gages (Tools No. 83793 and 83052). Instructions for performing this replacement are included on blueprint No. 84854, which is provided with this fixture.

b. If replacement of the copper fuel venturi extension tube is found to be necessary, do this, using the set of tools (Tool No. 800064) and fixture (Tool No. 800065). Instructions for performing this replacement are as follows:

(1) Insert bushing (Tool No. 800066-1) in housing and drill out tube, using drill (Tool No. 800067). Pick out remainder of tube.

(2) Tap, using tap (Tool No. 800068). (Use lard oil, Specification C-O-376, for tapping).

(3) Mount fixture on housing with bolt through impeller shaft rear oil seal sleeve hole. Insert new tube in tapped hole. Swing fixture so that the side of the tube is flat against the fixture and the end of the tube is against the pins. Clamp tubing snugly only and then clamp fixture tightly. Insert bushing (Tool No. 800066-2). Expand tubing in hole, using spinning tool (Tool No. 800069) and (Tool No. 800070) consecutively locating stop collar (Tool No. 800066-3) 5-29/32 in. from the end of the spinning tool. (Use white lead on spinning tools).

(4) Insert bushing (Tool No. 800066-5) in housing. Locate collar (Tool No. 800066-6) on drill (Tool No. 800071) 5-7/32 in. from the end of the drill. Remove excess metal resulting from elongation of tube spinning operation.

c. If replacement of the diffuser plate is found to be necessary, do this in accordance with the following instructions: Break the lock wire securing the diffuser plate attaching nuts and remove the nuts. Lift off the diffuser plate. If a brass shim has been previously installed between the diffuser plate and the supercharger rear housing, use the same shim, or a new shim of the same thickness, under the new diffuser plate. Install a new diffuser plate, and tighten the attaching nuts to the proper torque value. Refer to the Table of Limits in Section XII. Lockwire the nuts securely.

d. In cases where it is found necessary to replace the diffuser plate or the supercharger front or rear housing with a new part, it is recommended that a pinch fit be obtained between the diffuser plate and the supercharger front housing. The pinch fit at this location is controlled by installing a shim or shims between the diffuser plate and the supercharger rear housing. It is not necessary to check this pinch fit at overhaul on engines in which the original diffuser plate and supercharger front and rear housings are used, since the proper pinch fit is obtained at the factory upon initial assembly of the engine.

e. Check the fit between the diffuser plate vanes and the supercharger front housing at assembly of an engine, using a new diffuser plate or a new supercharger front or rear housing, in accordance with the following instructions: Place the diffuser plate in position on the supercharger rear housing. Insert and tighten the diffuser plate nuts, but do not lockwire the nuts at this time. Place the supercharger rear housing in position on the front housing parting flange without a gasket between. Make certain that the vanes of the diffuser plate are resting on the supercharger front housing.

f. Measure the clearance between the parting surfaces of the supercharger front and rear housings, using two feeler gages on diametrically opposite sides of the housings. Measure the thickness of the gasket used between the supercharger front and rear housings, using a micrometer and subtract .001 in. from

this measurement to allow for compressibility of the gasket. Subtract the figure thus obtained from the measured clearance between the supercharger front and rear housings. This final figure is the pinch fit which will be obtained between the diffuser vanes and the supercharger front housing when the nuts attaching the supercharger rear housing to the front housing are tightened. Refer to the Table of Limits in Section XII for the proper pinch fit at this location. If the figure obtained above representing this pinch fit is less than the minimum figure given in the Table of Limits, it will be necessary to install one or two diffuser plate shims, as required, to obtain the proper pinch fit.

g. Lift the supercharger rear housing from the front housing and remove the diffuser plate nuts and the diffuser plate. Install the shim or shims, if necessary, on the diffuser plate parting surface, and assemble the diffuser plate to the supercharger rear housing. Tighten the diffuser plate attaching nuts and lockwire securely.

h. If replacement of the impeller shaft rear sleeve is found to be necessary, do this in accordance with the following instructions: For engines incorporating a sleeve locked with a pin, this pin must be removed prior to removal of the sleeve. To remove locking pin, insert jig (Tool No. 800603) in the sleeve, insert the locating pin (Tool No. 800603-8) in the jig and adjust the knurled nut so that the locating pin enters the locking pin hole in the sleeve freely. Clamp the jig tight.

CAUTION

With the jig clamped tight, the locating pin should be free in the pin hole. Insert drill bushing (Tool No. 800603-3) in jig. Insert the drill (Tool No. 84455) in a drill spindle and drill into the locking pin approximately 1/8 in. deep. Replace bushing (Tool No. 800603-3) with bushing (Tool No. 800603-5), replace drill (Tool No. 84455) with drill (Tool No. 800604) and cut the head of the pin away. Make certain not to drill into the metal under the head of the pin. Remove the jig and drive out the old pin, using punch (Tool No. 802183).

i. For removing the sleeve, place collar (Tool No. 800758) on an arbor press with the large opening up. Place the housing on the collar, with the studded side down. Insert plug (Tool No. 800602-1) in the sleeve and press the sleeve out. Clean up the bore of the housing and remove any burrs.

NOTE

If the sleeve is locked with a screw, remove the screw, then proceed as above.

j. For installing pin-lock type sleeves, place a collar (Tool No. 800758) on an arbor press. After heating the housing to 107 deg C (225 deg F) for 1-1/2 hours, place it on the collar with the studded side up. Insert plug (Tool No. 800602-1) in sleeve, and screw nut (Tool No. 800602-2) down on the flange of the sleeve. Insert the plug in the housing, with one of the sleeve holes in line with the top center tapped hole used for fastening the impeller shaft retainer. Press the sleeve into the housing.

k. For this operation, where a screw lock type sleeve is used, omit the use of collar (Tool No. 800758) and plug (Tool No. 800602-1). Drop the sleeve into the heated housing, line up the two tapped holes in the sleeve with the holes in the housing, using the two plugs (Tool No. 801206) to hold the sleeve in place until tight.

l. To drill the lock pin hole, insert the jig (Tool No. 800603) in the sleeve. Insert the drill bushing (Tool No. 800603-4) in the jig. Retract the locating pin inside about 3/8 in. Insert locating pin (Tool No. 800603-10) in the bushing and into the locating pin hole in the housing. Adjust the large knurled nut and clamp the jig tight.

CAUTION

With the jig clamped tight the locating pin should be free in the pin hole.

m. Remove the locating pin and replace bushing (Tool No. 800603-4) with bushing (Tool No. 800603-3). Hold drill (Tool No. 84455) in the drill press spindle. With the housing held at a 35 deg angle, drill the pin hole in the sleeve. Replace drill (Tool No. 84455) with reamer (Tool No. 82486) and ream the hole in the sleeve. Check the reamed hole with gage (Tool No. 82231).

n. Insert the locking pin in the housing and drive it in, using punch (Tool No. 802183). Check to insure that the pin does not protrude into the bore of the sleeve. Peen metal round the head of the pin, using a center punch.

o. For grinding this sleeve, mount the fixture (Tool No. 84294) on the face plate of an internal grinder or

a lathe and indicate pilot diameter and face to run true. Clamp gage bar (Tool No. 801203-1) on the front end of the housing, using two screws (Tool No. 801203-2). Clamp the housing to fixture (Tool No. 84294), using seven 3/16-24 hex nuts and seven 5/16 in. washers on the studs of the fixture. Grind the inside of the sleeve and check the size of the hole with the following gages:

Tool No. 801201 for a final finished inside diameter of 2.192 to 2.193 in.

Tool No. 801473 for a final finished inside diameter of 2.197 to 2.198 in.

Tool No. 801489 for a final finished inside diameter of 2.202 to 2.203 in.

Hold to the lower limits wherever possible.

p. Grind the face of the sleeve flange and use flush pin gage (Tool No. 801205).

NOTE

When the grinding is done on a lathe a portable tool post grinder is required.

q. For honing the inside diameter of the rear supercharger housing sleeve, place the fixture (Tool No. 84294) on a drill press table. Clamp the housing and sleeve assembly on the fixture (Tool No. 84294), using seven 5/16-24 hex nuts and seven 5/16 in. washers on the studs of the fixture. Hold the hone (Tool No. 802116) in the drill press spindle and run the spindle at about 50 rpm and hone the sleeve by moving the hone up and down in the sleeve. Hone the inside of the sleeve and check the finished hole with the following gages:

Tool No. 801202 for an inside diameter of 2.192 to 2.193 in.

Tool No. 801474 for an inside diameter of 2.197 to 2.198 in.

Tool No. 801488 for an inside diameter of 2.202 to 2.203 in.

r. Stone all sharp corners. Use a good grade of kerosene as a lubricant.

31. IMPELLER AND IMPELLER SHAFT.

a. If replacement of the impeller shaft front and rear bushings is found to be necessary, do this in accordance with the following instructions: Clamp fixture (Tool No. 801001) on a lathe face plate. Indicate the bore of the fixture to run true. Install adapter (Tool No. 801017) in the fixture, and install the impeller shaft in the adapter and clamp. If the impeller shaft is provided with a centering ring washer pressed into the gear end of the shaft, remove the ring, using puller (Tool No. 800819) before installing the shaft in the fixture.

b. Bore out the old bushings to a diameter of 1.450 in., leaving a thin shell of each bushing remaining in the shaft. Refer to Figure 157. Remove the shaft from the fixture, break out the remaining shells, and clean up the bushing bores in the shaft. Check to insure that the proper tight fit of the bushings in the shaft will be obtained. Refer to the Table of Limits in Section XII.

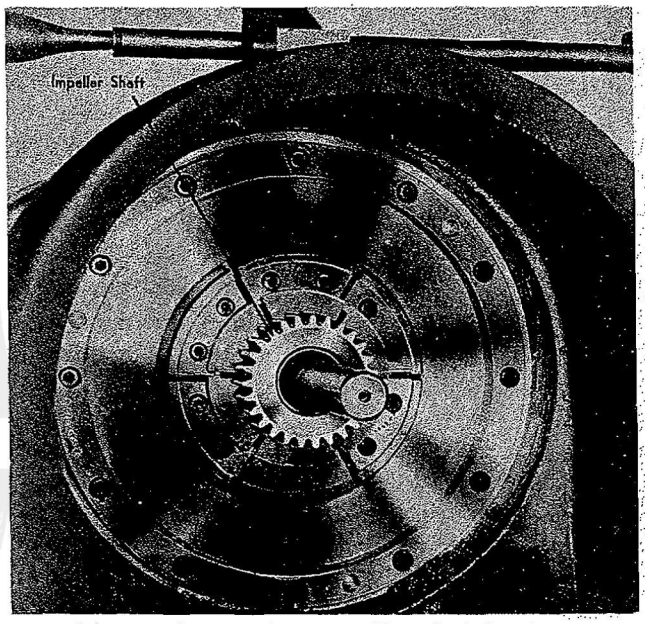

Figure 157—Boring Impeller Shaft Bushing

c. Press in the new front bushing, using pressing-in plug (Tool No. 800091 or Tool No. 800092). Tool No. 800091 is used for impeller shafts having an over-all length of 7.36 in., and Tool No. 800092 is used for impeller shafts having an overall length of 7.26 in. Press in the new rear bushing, using pressing-in plug (Tool No. 83357, Tool No. 800093, or Tool No. 800053). Tool No. 83357 is used for impeller shafts having an overall length of 7.26 in., except shafts which are provided with a centering ring washer pressed into the gear end of the shaft. Tool No. 800093 is used for impeller shafts which are provided with a centering ring washer pressed into the gear end of the shaft. Tool No. 800053 is used for impeller shafts having an overall length of 7.36 in. In all cases, when pressing in impeller shaft front and rear

bushings, press in the bushing, using the proper plug until the shoulder on the plug or on the bushing is bottomed on the rear end of the impeller shaft. The bushing is then installed to its proper depth.

d. Reinstall the impeller shaft in the lathe fixture and adapter (Tools No. 801001 and 801017), and clamp. Finish bore the bushings to a diameter of 1.3120 to 1.3130 in. Use plug gage (Tool No. 82371) to check the size of the bushing holes after finish boring. Use the alignment plug (Tool No. 82361) to check the alignment of the bushing holes after finish boring. Remove the impeller shaft from the fixture and remove the tools from the lathe.

e. If a centering ring washer pressed into the gear end of the impeller shaft is used, install the washer, using pressing-in plug (Tool No. 83357).

f. Fit new oil seal rings in the impeller shaft front and rear oil sleeves, insuring that the proper ring side clearance and gap are obtained. Refer to the Table of Limits in Section XII. Do not lap bronze oil seal rings.

g. If the bronze spherical impeller shaft thrust ring and the spherical counterbore in the impeller shaft retainer are scratched, burred, or scored, lap the mating spherical surfaces of these parts, using lapping fixture (Tool No. 83870) and lap (Tool No. 83891). To lap the spherical surface on the impeller shaft retainer, attach the lap to the arbor of the fixture and attach the retainer to the body of the fixture, using five screws. Install the arbor in the fixture and lap, using 3M oil mix lapping compound, Grade 600, or equivalent. To lap the spherical thrust ring, remove the lap from the arbor and install the thrust ring on the tapered plug on the end of the arbor. Lap the thrust ring into the retainer, using the same lapping compound.

31A. ACCESSORY DRIVE AND STARTER SHAFT.

a. When the wall of the recess in the gear hub has been worn by the impeller shaft retainer oil seal ring, regrind the surface as required. Remove only sufficient metal to produce a smooth unbroken surface.

b. Chuck the rear hub journal in a lathe, using soft metal or paper to protect the highly finished surfaces of the journal. Support the propeller end of the shaft by a center in the lathe tail stock. Indicate the front and rear impeller shaft journals to run true within .001 in. full indicator reading.

c. Mount a coarse grit taper pencil wheel having a width of 1/2 in. and a 3/4 in. diameter on a tool post grinder. Mount the grinder at an angle with the accessory drive and starter shaft to give clearance to the grinder motor housing, and so that only the large end diameter of the taper wheel bears against the work. Grind the full width of the gear recess, using a fine feed. Indicate the finished surface to run true within .001 in. full indicator reading.

32. SUPERCHARGER REAR HOUSING COVER.

a. If any of the bushings in the supercharger rear housing cover need replacing, this can be accomplished by using tool set No. 83871. This set of tools contains all the tools necessary for replacing all bushings in the supercharger rear housing cover. The use of the fixtures and tools included in this set insures that the proper location of bushing holes will be obtained upon installation of new bushings. This is extremely important in order that the accessory driving gears which pilot in the bushings will be properly aligned and meshed. For location of bushings refer to Figure 158.

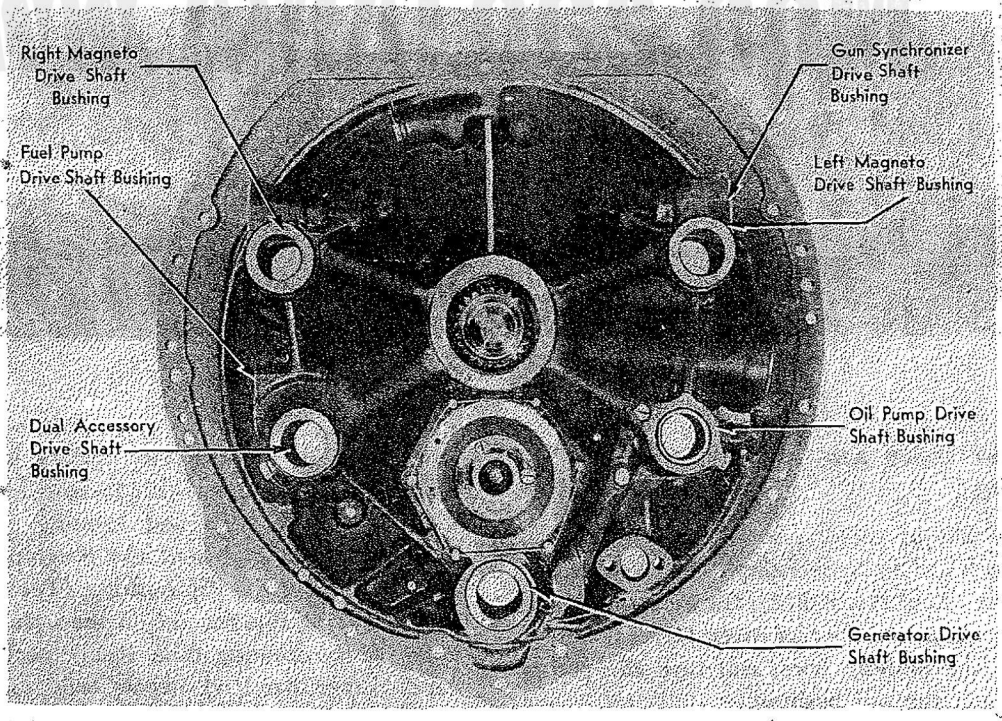

Figure 158—Location of Bushings in Supercharger Rear Housing Cover

b. When a bushing is removed from the supercharger rear housing cover, clean the bushing hole in the cover, using crocus cloth and gasoline. Inspect the oil passages and grooves for cleanliness. Insure that the proper fit of the new bushing in the bushing hole in the cover is obtained. Refer to the Table of Limits in Section XII. Lubricate the outside diameter of each bushing with engine oil before pressing the bushing into the rear cover. (Tools No. 83875-1 and 83907-19) in an arbor press. Support the rear cover on collar (Tool No. 83907-18) during this operation to prevent damaging the starter attaching studs. Insure that one of the three openings in the bushing is lined up with the oil passage which leads to the Cuno oil filter hole, in order that the oil flow will not be restricted in this location.

c. To ream the bushing bore to size, attach the rear

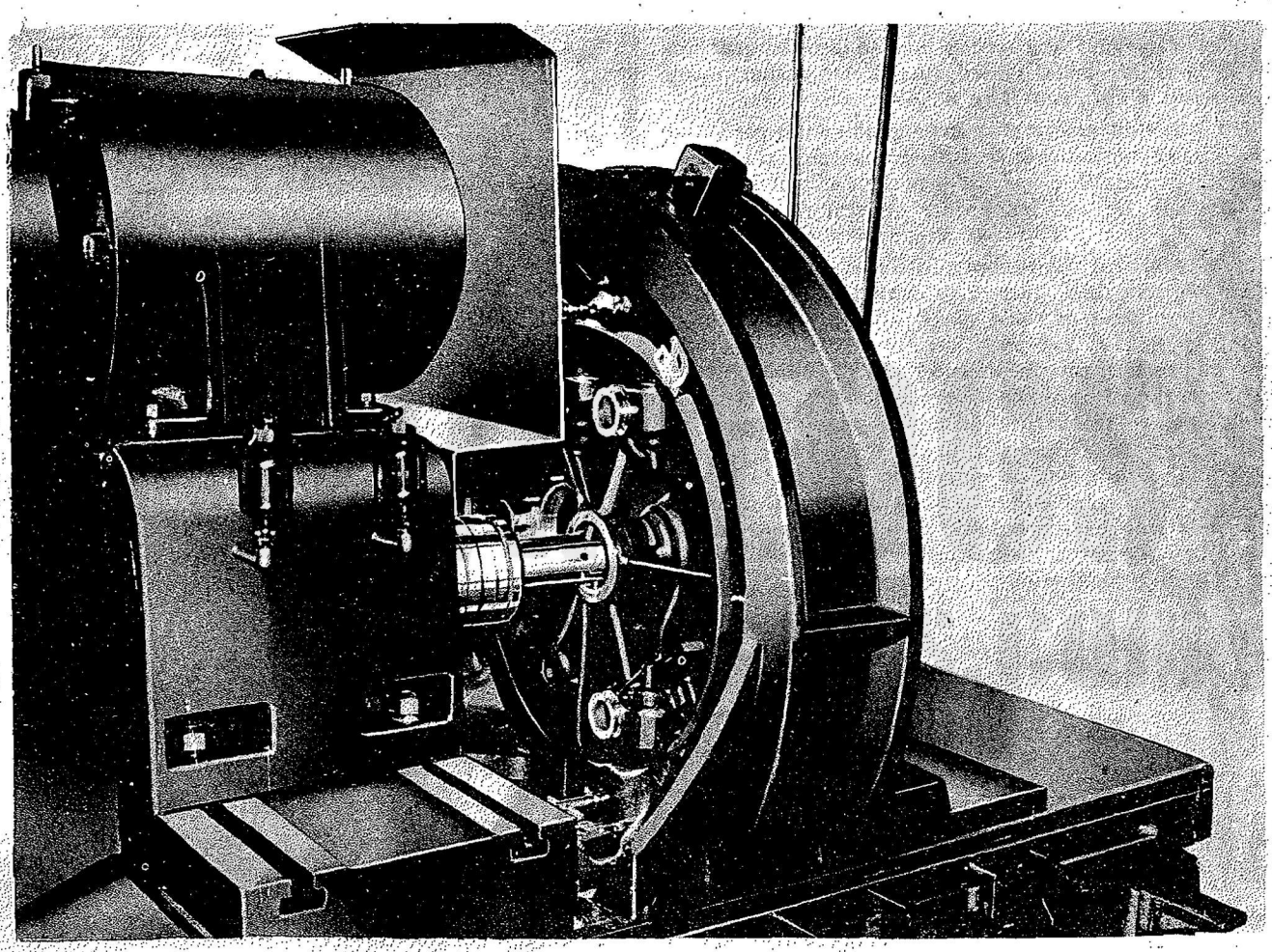

Figure 159—Reaming Starter Shaft Bushing

33. ACCESSORY DRIVE AND STARTER SHAFT BUSHING.

a. If replacement of the accessory drive and starter shaft bushing is found to be necessary, remove the bushing, using puller (Tool No. 83872). Install the locating plate on the starter pad on the rear cover, locate the pilot on the tool in the bushing bore, and turn the puller screw to push out the old bushing.

b. Press in the new bushing, using installing tools cover to fixture (Tool No. 82207) by means of the starter attaching studs, with locating disks (Tools No. 83907-1, -2, and -3) and locating pins (Tool No. 83907-4) in place. Install the roughing reamer (Tool No. 802192), in its slip bushing (Tool No. 83907-13), and insert the slip bushing in the fixture, insuring that it enters the locating disk. Ream the bushing bore by hand. Large overhaul depots may ream by machine as shown in Figure 159. Ream, using the finishing reamer (Tool No. 802193) and the same slip bushing

in the same manner. Check the bushing bore for size, using plug gage (Tool No. 83878-1).

34. MAGNETO DRIVE GEAR SHAFT BUSHING.

a. If replacement of either of the magneto drive gear shaft bushings is found to be necessary, it is first necessary to remove the gun synchronizer drive shaft thrust bushing. This thrust bushing will interfere with the magneto drive gear shaft bushing upon removal unless it is removed first. Drill through the thrust bushing, using a standard 11/16 in. diameter drill and drill bushing (Tool No. 83907-17). Refer to Figure 160. Tap the drilled hole, using a standard 3/4-16 tap. Remove the thrust bushing, using puller (Tools No. 83907-15, -16, and -17). Refer to Figure 161. Press out the magneto drive gear shaft bushing, using plug (Tool No. 83907-20) and collar (Tool No. 83907-24) in an arbor press. Refer to Figure 162.

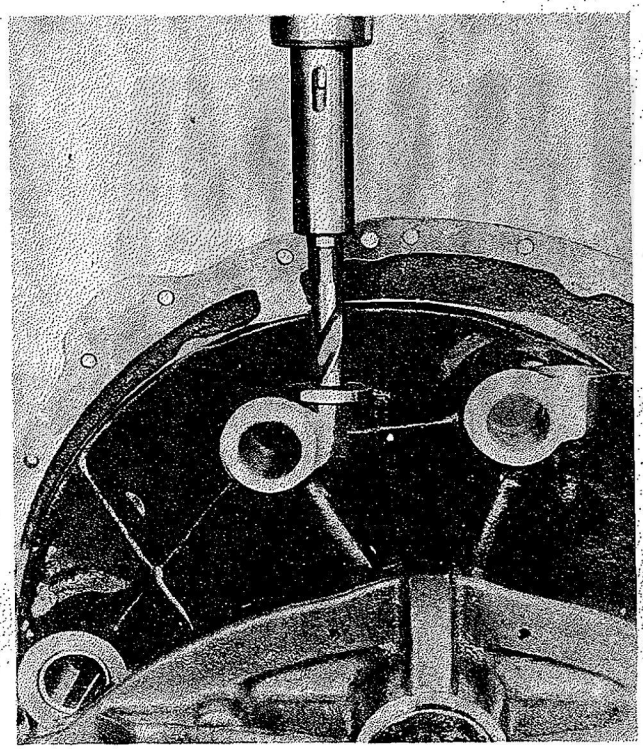

Figure 160—Drilling Fuel Pump Drive Shaft Thrust Bushing

b. Press in the new bushing, using installing tools (Tools No. 83907-20 and -23) in an arbor press. Support the rear cover on collar (Tool No. 83875-4) during this operation to protect the magneto attaching studs. Refer to Figure 163.

c. It is necessary to machine a quarter-cut in the new bushing in the location of the gun synchronizer

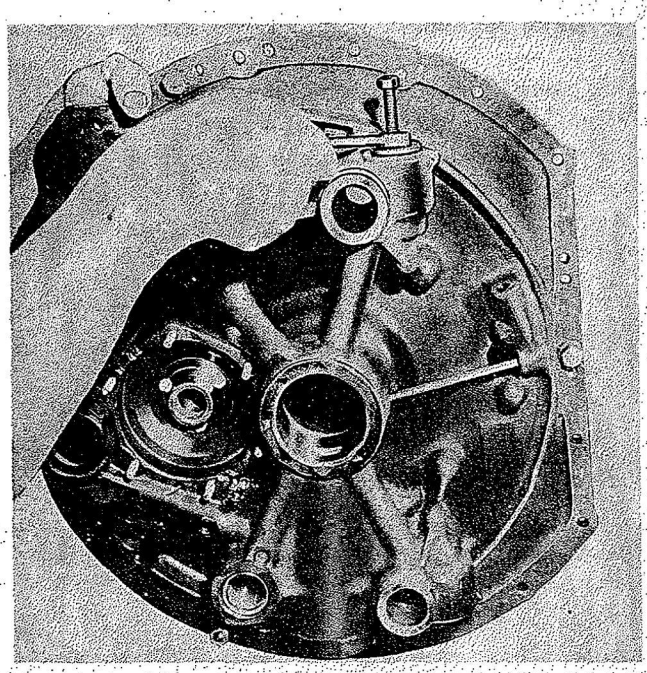

Figure 161—Removing Drive Shaft Thrust Bushing

drive shaft. Attach the rear cover to fixture (Tool No. 82207) by means of the magneto attaching studs, with locating pins (Tool No. 83907-4), spacers (Tools No. 83879-1, -3, and -4), and screws (Tool No. 83879-10) in place. Clamp the fixture to a drill press table so that the gun synchronizer drive shaft support pilot is located directly under the drill press spindle. Install roughing cutter (Tool No. 82247) in the spindle of the drill press and quarter-cut the bushing. Repeat this operation, using finishing cutter (Tool No. 82246).

d. Remove the fixture and rear cover together from the drill press and ream the bushing bore to size. Install the roughing reamer (Tool No. 802153) in its slip bushing (Tool No. 83907-12), install the slip bushing and reamer in the fixture, and ream the bushing bore by hand. Ream, using the finishing reamer (Tool No. 802154) and the same slip bushing in the same manner. Check the bushing bore for size, using plug gage (Tool No. 83908).

e. Press in the new gun synchronizer drive shaft thrust bushing.

35. DUAL ACCESSORY DRIVE GEAR SHAFT BUSHING.

a. If replacement of the dual accessory drive gear shaft bushing is found to be necessary, do this in the same manner, using the same tools, as previously described for the magneto drive gear shaft bushings. First remove the fuel pump drive shaft thrust bush-

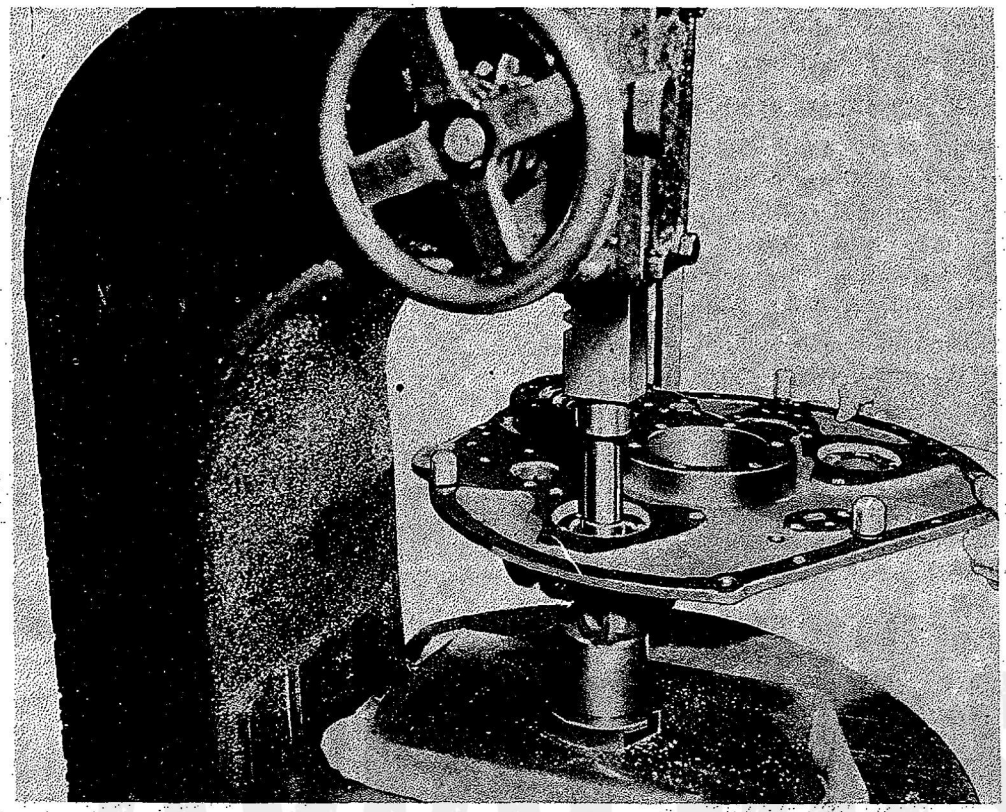

Figure 162—Pressing Out Magneto Drive Gear Shaft Bushing

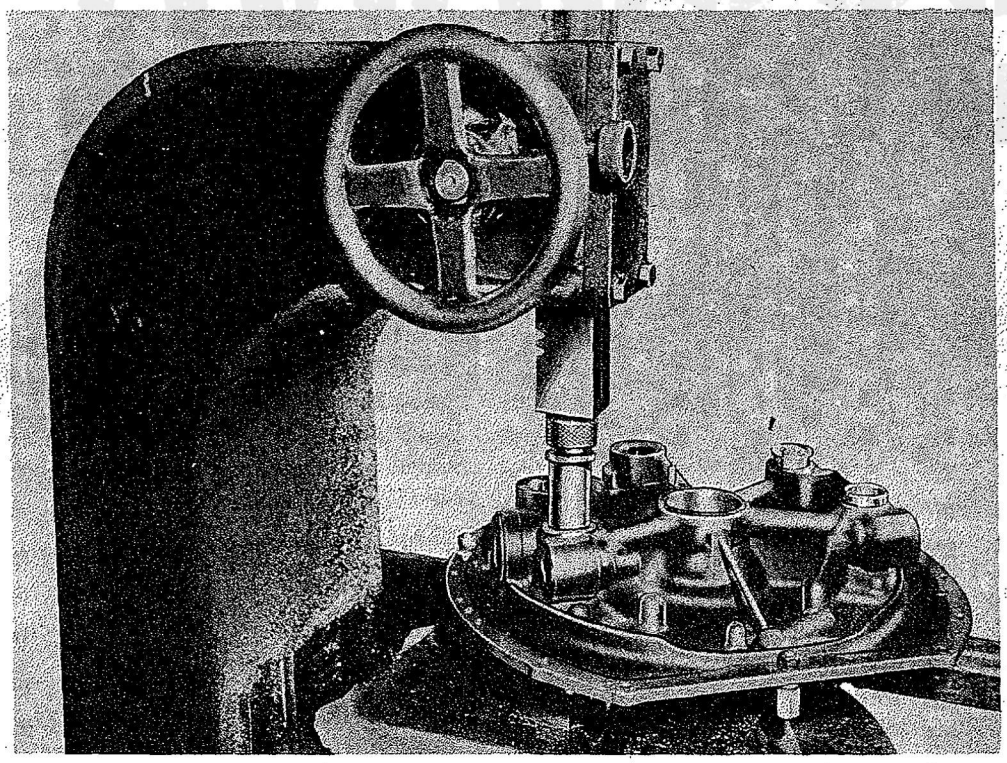

Figure 163—Pressing in Magneto Drive Gear Shaft Bushing

ing, then press out the dual accessory drive gear shaft bushing. Press in, quarter-cut, and ream the new bushing, and press in a new thrust bushing.

36. OIL PUMP DRIVE GEAR SHAFT BUSHING.

a. If replacement of the oil pump drive gear shaft bushing is found to be necessary, remove the old bushing, using plug (Tool No. 83907-20) and collar (Tool No. 83907-21), in an arbor press. Press in a new bushing, using installing tools (Tools No. 83907-20, -22, and -23), in an arbor press. Support the rear cover on collar (Tool No. 83907-21) during this operation to protect the oil pump attaching studs. Insure that the oil groove in the bushing is aligned with the oil feed passage in the rear cover.

b. To ream the bushing bore to size, attach the rear cover to fixture (Tool No. 82207) by means of the oil pump attaching studs, with spacer (Tool No. 83879-2) in place. Install the roughing reamer (Tool No. 802153) in its slip bushing (Tool No. 83907-12), install the tools in the fixture, and ream the bushing bore by hand. Ream, using the finishing reamer (Tool No. 802154) and the same slip bushing in the same manner. Check the bushing bore for size, using plug gage (Tool No. 83908).

37. GENERATOR DRIVE GEAR SHAFT BUSHING.

a. If replacement of the generator drive gear shaft bushing is found to be necessary, remove the old bushing, using plug (Tools No. 83875-2 and 83907-20). Support the rear cover on collar (Tool No. 83875-3) during this operation to protect the generator attaching studs. Insure that the oil groove in the bushing is aligned with the oil feed passage in the rear cover.

b. To ream the bushing bore to size, attach the rear cover to fixture (Tool No. 82207) in the same manner as previously described for reaming the accessory drive and starter shaft bushing. Install roughing reamer (Tool No. 802153) in its slip bushing (Tool No. 83907-12). Install these tools in the fixture, insuring that the slip bushing enters its locating disk. Ream the bushing bore by hand. Ream, using the finishing reamer (Tool No. 802154) and the same slip bushing in the same manner. Check the bushing bore for size, using plug gage (Tool No. 83908).

38. INTERMEDIATE IMPELLER DRIVE SHAFT REAR BUSHING.

a. If replacement of the intermediate impeller drive shaft rear bushing is found to be necessary, remove the bushing, using puller (Tool No. 800691) after removing the three attaching screws. Press in the new bushing, using installing tool (Tool No. 800781-1). Take care to align the screw holes in the bushing with the tapped holes in the rear cover, using the locating pin (Tool No. 800781-2). The screw holes in the bushing and rear cover are unequally spaced. Support the rear cover on suitable blocks during these operations to prevent damaging the studs on the rear side of the rear cover.

b. To ream the bushing bore to size, attach the fixture (Tool No. 83873) to the rear cover, locating the two pilots on the fixture in the generator drive gear bushing and the accessory drive and starter shaft bushing. Tighten the nuts and washers on the three studs on the fixture to secure the fixture to the rear cover. Attach the rear cover to fixture (Tool No. 82207). Install the roughing reamer (Tool No. 802151) in its slip bushing (Tool No. 83907-12), install these tools in the fixture, and ream the bushing bore by hand. Ream, using the finishing reamer (Tool No. 802152) and the same slip bushing in the same manner. Check the bushing bore for size, using plug gage (Tool No. 83877).

39. INTERMEDIATE IMPELLER DRIVE GEAR BUSHING.

a. If replacement of the intermediate impeller drive gear bushing is found to be necessary, use for this purpose the following tools: Drill jig and drill bushings (Tool No. 84321), removing and installing plug and collars (Tool No. 83019), lock pin hole reamer (Tool No. 84322), lock pin hole plug gage (Tool No. 83793), boring fixture (Tool No. 83961), plug gage (Tool No. 83023), and the set of tools (Tool No. 900115). Detailed instructions for replacing, pinning, and finish boring this bushing are included on blueprint No. 900115, which is furnished with the set of tools.

40. GENERATOR AND MAGNETO DRIVE OIL SEALS.

a. Synthetic rubber oil seals of one piece construction are used at these locations, and are replaced at each overhaul.

Paragraphs b. and c. deleted in revision dated 5 October 1945.

41. GUN SYNCHRONIZER IMPULSE GENERATOR DRIVE SHAFT SUPPORT BUSHINGS.

a. Place the gun synchronizer impulse generator drive shaft support on the base (Tool No. 800753-4), install block (Tool No. 800753-2) and its locking pin (Tool No. 800753-3) in the arbor (Tool No. 800753-1), place on an arbor press table and press out the bushing.

b. To install these bushings insert the arbor (Tool No. 800754-4) through the base (Tool No. 800754-2) and bushing support, and place the threaded nut (Tool No. 800754-3) with the bushing to be installed under it, in the other end and engage the threads. Screw the nut down until the bushing bottoms on the support.

c. Using the base (Tool No. 800754-2) and the support in a drill press, broach the bushings, using the broach (Tool No. 800736).

d. Use plug gage (Tool No. 82364) for checking the size of the broached bushings. Use length gage (Tool No. 800728) for checking the distance from the support attaching flange to the end of the bushing. Use snap gage (Tool No. 800841) when a support incorporating a diagonal drain hole near the flange is used.

42. CUNO OIL FILTER.

a. If replacement of the Cuno oil filter cartridge, relief valve, or relief valve spring is found to be necessary, do this in accordance with the following instructions: Remove the two No. 10-32 hexagonal nuts at the end of the cartridge support rods, after bending down the tab locking washers. The nuts are found at the end of the cartridge opposite from the filter attaching flange, and serve to hold the cartridge in place in the head. Slide the unit cartridge assembly along the support rods away from the filter head. This releases the relief valve assembly, permitting the relief valve and relief valve spring to fall out. Manual effort should be sufficient to move the cartridge assembly along the support rods. Do not hammer or pry the cartridge in an attempt to hasten this operation.

b. Hold the filter head with the support rod pointing up, place the new relief valve spring in position in the filter head, and place the new relief valve in position over the spring. Install the new unit cartridge by sliding the cartridge carefully along the support rods. Guide the relief valve assembly into the filter head during the assembly of the cartridge. Use for this purpose the eraser end of a common pencil on filters which do not have a sludge tube, or a small diameter rod on filters which are equipped with a sludge tube. After assembly of the cartridge, check to insure that the relief valve slides freely in the recess in the head. Make certain that the slot in the end of the cartridge spindle engages the driving pin in the clutch hub. The assembly is correctly made when the unit cartridge seats firmly against the filter head and the threaded ends of the support rods protrude beyond the end of the cartridge to permit installation of the tab washers and nuts.

c. Install the two tab washers and nuts. Use new tab washers at every installation. Lock each nut by bending the tab up to a flat on the nut.

d. Recheck the operation of the Cuno oil filter in the Cuno test fixture after the installation of the new parts. Refer to Section VI, paragraph 6 *e.*

42A. PRESSURE OIL STRAINER.

a. If the oil strainer screen assemblies are bent or broken, all such assemblies will be repaired in accordance with the following instructions:

(1) Remove the oil strainer screen retainer and pin assembly from the damaged oil strainer screen and oil strainer screen supporting sleeve.

(2) Remove the oil strainer pilot extension from the damaged oil strainer screen and oil strainer screen supporting sleeve.

(3) Clean the retainer and pin assembly and pilot extension thoroughly.

b. Install a new oil strainer screen and oil strainer screen supporting sleeve on the oil strainer pilot extension and oil strainer screen retainer and pin assembly by silver soldering (wire, class 4, Specification QQ-S-561). Care must be taken to insure that the dowel pin in the retainer is aligned correctly with the oil strainer pilot extension prior to soldering.

c. If the relief valve or the spring is unsatisfactory, replace the strainer assembly.

43. FUEL PUMP DRIVE SHAFT SUPPORT BUSHINGS.

a. If replacement of the fuel pump drive shaft support bushings is found to be necessary, do this in the following manner:

b. Place the fuel pump drive shaft support in the lathe fixture (Tool No. 83826) with adapter (Tool No. 83827). Bore out the bushings taking care not to remove any material from the support itself.

c. For installation of these bushings, place the fuel pump drive shaft support on the base (Tool No. 83835-1) with the base resting on an arbor press table. Place the bushing on the support making certain that the oil groove is located 90 deg from the lock pin in the base (Tool No. 83835-1). Place the plug (Tool No. 83835-2) through the bushing, bushing support, and base until the larger portion shoulders against the bushing. Using the arbor press, press in the bushing until it bottoms against the support.

d. Place the fuel pump drive shaft support on the base (Tool No. 800031) and install in a drill press. Using a .6260 ± .0005 in. broach (Tool No. 800032), broach the bushing to size.

e. Use plug gage (Tool No. 84369) and flush pin gage (Tool No. 800033) for checking the size of the bushing hole and for installation, respectively.

44. CRANKSHAFT FRONT AND REAR MAIN BEARINGS.

a. For instructions regarding the repair and handling of the crankshaft front and rear main bearings, refer to Section VII, paragraph 4.

45. CRANKSHAFT FRONT END.

a. Remove scratches or high spots from the outside diameter of the crankpin by light stoning, using a fine round stone. Use a rocking motion when stoning to avoid flat spots. Be particularly careful to remove burred, scratched, or galled areas that may be found on the clamping surface at the end of the crankpin. Polish with crocus cloth and light oil after stoning. Wash the entire crankshaft front end thoroughly with gasoline, and dry in an air blast.

b. If the crankpin is scored to such an extent that it may not be repaired by stoning, the crankpin may be ground to as much as .010 in. undersize diameter at overhaul bases properly equipped to perform this rework. This is necessary when the engine has been operated with insufficient lubrication or with foreign material in the oil. If it is found that the crankpin requires regrinding exceeding the above limit, the crankshaft rear section must be replaced with one having an undersized clamping diameter.

NOTE

A master rod bearing having an undersize inside diameter must be used when the proper clearances cannot be maintained with a crankpin that has been ground undersize. AAF activities apply to Headquarters, Air Service Command, and Navy activities will contact the Aviation Supply Office, Philadelphia, Penn., for disposition instructions in regard to these parts.

c. If replacement of a crankshaft oil tube in the crankpin is found to be necessary, drive out the old tube using punch (Tool No. 801317). Hold the crankshaft front end in a milling machine vise, clamping on the counterweight end, supporting the crankshaft so that the oil tube hole in the crankpin is pointing directly upwards. Insert support (Tool No. 801295) in the crankpin bore, and insert the new oil tube in the tapered hole so that it rests on the bottom of the slot in the tool. Lock the installing tool in place. Flare the tube against the tapered sides of the hole using the tapered punch (Tool No. 801325). Install the crankshaft and vise on a drill press table, locating the tube directly under the drill press spindle. Spin the tube into place using spinner tool (Tool No. 83591). Spin the shoulder on the tube at the small end of the tapered hole using spinning tool (Tool No. 802220). Use castor oil and white lead as a lubricant during these spinning operations. Form a radius at the outer end of the tube using cutter, pilot, and holder (Tool No. 801322). Remove the tools from the crankshaft and remove the crankshaft from the vise.

d. Polish the rear face of the front crankshaft cheek adjacent to the crankpin fillet to obtain a finish of 13 to 15 micro-inches. It is recommended that this highly polished finish be maintained on this surface in order to prevent mutilation and excessive wear of the master rod end seal disk. Polish in accordance with the following instructions: Wrap masking tape around the crankshaft front main bearing journal; place the crankshaft front extension in the fixture (Tool No. 801627) and clamp the fixture to a drill press table, locating the crankpin centrally under the drill press spindle.

e. Install the polishing tool (Tool No. 801333) in the drill press chuck. Insert four pieces of Aloxite No. 320 polishing cloth into slots equally spaced around the tool. Cut away part of the polishing cloth, if necessary, in order to prevent it from bearing on the crankpin shoulder radius. Wrap masking tape or heavy waxed paper around the crankpin in the direction of tool rotation to protect the surface of the crankpin while polishing. Castor oil applied to the crankpin may be used to hold the waxed paper in place. Lower the polishing tool into position over the crankpin, and polish the front crankcheek by turning the tool at a speed of approximately 600 rpm, exerting a moderate pressure of the tool on the work. Refer to Figure 164. A worn cloth is essential for a high finish. Determine the finish obtained in polishing by comparison with the 15 micro-inch finish reference block (Tool No. 801762).

f. The tools required for performing this polishing operation form part of the set of tools provided under Tool No. 801850.

g. If replacement of the crankshaft front end bushings is found to be necessary, do this in the following

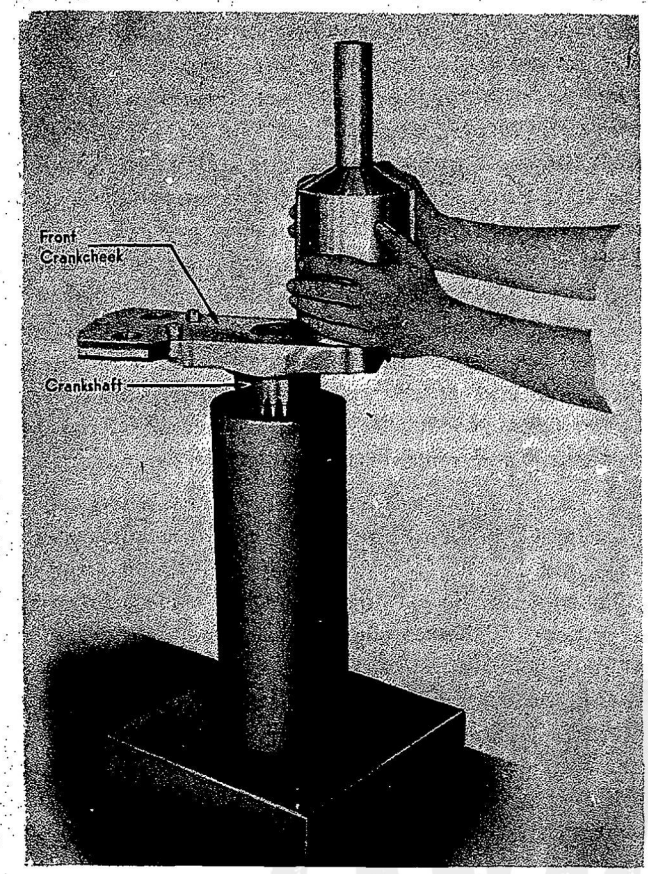

Figure 164—Polishing Crankshaft Front End Adjacent to Crankpin Fillet

manner: Place the base (Tool No. 83523) on an arbor press table and place the crankshaft horizontally on the base so that the bushing to be removed is located over the large hole in the base. Press out the bushing using plug (Tool No. 84809). Remove burrs from the bushing hole in the crankshaft and smooth the inside diameter of the hole using crocus cloth and gasoline. Check the inside diameter of the bushing hole and the outside diameter of the new bushing to insure that the proper fit will be obtained. Refer to the Table of Limits in Section XII. When the bushings originally installed in the front crankshaft are worn, pitted or galled, they may be removed, rotated 90°, and reinstalled without further repair, according to the directions given below.

b. Apply a thin coating of AN-C-53, or its equivalent, to the new bushing. Place the crankshaft on base (Tool No. 83523) on an arbor press table, and press in the new bushing using plug (Tool No. 84809) and collar (Tool No. 84811). Install the collar on the plug so that the step on the collar is against the bushing. This insures that the bushing will be installed to the proper depth.

i. If replacement of the crankshaft front counterweight bushings is found to be necessary, do this in the following manner: Place the base (Tool No. 83523) on an arbor press table and place the front counterweight horizontally on the base so that the bushing to be removed is located over the small pilot hole in the base. Press out the bushing using plug (Tool No. 84809), piloting the shank of the plug in the pilot hole in the base. Remove burrs from the bushing hole in the counterweight and smooth the inside diameter of the hole using crocus cloth and gasoline. Check the inside diameter of the bushing hole and the outside diameter of the new bushing to insure that the proper fit will be obtained. Refer to the Table of Limits in Section XII. When the bushings are found to be worn, pitted or galled, but are otherwise satisfactory for continued service, they may be rotated 90° from their original position and reinstalled without further repair.

j. Apply a thin coating of AN-C-53 to the new bushing. Attach the adapter (Tool No. 84810) to the stop plate (Tool No. 83445) by means of two No. 10—32 flat head screws. Insert the stop plate into the slot in the counterweight so that the edge of the adapter contacts the flat side of the counterweight. Tighten the two wedges into the slots provided in the stop plate so that the side of the stop plate is contacting the side of the counterweight in which the new bushing is to be installed. Place the counterweight on base (Tool No. 83523) on an arbor press table, and press in the new bushing using plug (Tool No. 84809) until the bushing is bottomed on the stop plate. The bushing is then installed to its proper depth.

k. When the gritblasted surface of the counterweight pins has been removed during engine operation, the surface may be renewed. Blast the entire bearing surfaces with a No. 60 metallic grit in an air cabinet, using an air pressure of between 80 and 90 lb per sq in. Apply the gritblasting evenly to ensure that the pin will not be made out of round or tapered. Lead plating of the gritblasted surfaces is no longer necessary, but when the lead plated counterweight pins are encountered at overhaul, the plating need not be removed unless reconditioning of the surfaces is necessary.

46. CRANKSHAFT REAR END.

a. Polish the front face of the crankshaft rear adjacent to the crankpin hole to obtain a finish of 13 to 15 microinches. It is recommended that this highly polished finish be maintained on this surface in order to prevent mutilation and excessive wear of the master rod end seal spacer. Refer to Figure 165 for a sketch showing the area to be

polished. Prepare the crankshaft rear end for polishing in the following manner: Bolt the holding plate (Tool No. 801846-1) vertically and firmly to a solid support. Attach the fixture (Tool No. 801846-2) to the holding plate. Spread the clamping joint of the crankshaft rear using the spreader plug (Tool No. 84765-1), plate (Tool No. 84765-2) and screw (Tool No. 84699), in order to permit installation of the crankshaft rear on the fixture. Install the crankshaft rear on the plug on the fixture with the rear end toward the fixture, so that approximately 1/32 in. clearance exists between the crankshaft rear extension and the fixture. Remove the spreading tools from the crankshaft rear and install the clamping cap screw. Clamp the crankshaft rear to the fixture by tightening

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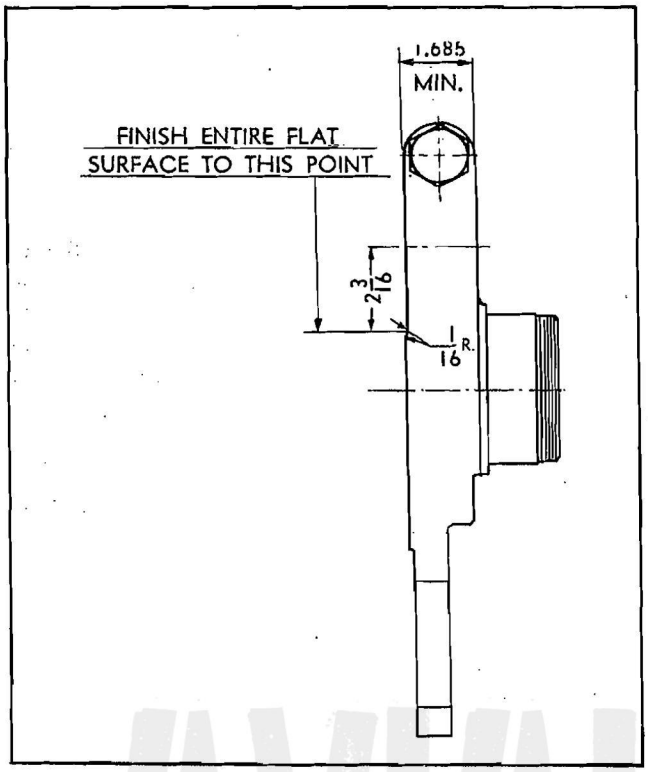

Figure 165—Polished Area of Front Face of Crankshaft Rear

the cap screw to the proper stretch, using wrench (Tool No. 80309) and extension (Tool No. 80198). Refer to the Table of Limits in Section XII. Remove the fixture and crankshaft rear main section from the holding plate.

b. Polish the front face of the crankshaft rear adjacent to the crankpin hole in the following manner: Wrap a strip of crocus cloth around a parallel bar of convenient size. Polish the part, using kerosene or Varsol as a lubricant. Refer to Figure 166. Determine the finish obtained by comparison with the 15 microinch finish reference block (Tool No. 801762). Check the polished surface for squareness using the bluing gage (Tool No. 801846-9) and bushing (Tool No. 801846-4). Measure the width of the crankshaft rear adjacent to the crankpin hole to insure that it is greater than the minimum permissible width of 1.685 in. Refer to Figure 167.

c. The tools required for performing this polishing operation form part of the set of tools provided under Tool No. 801850.

d. Press out the bushing bearing in the crankshaft rear section just far enough to clear the oil passages

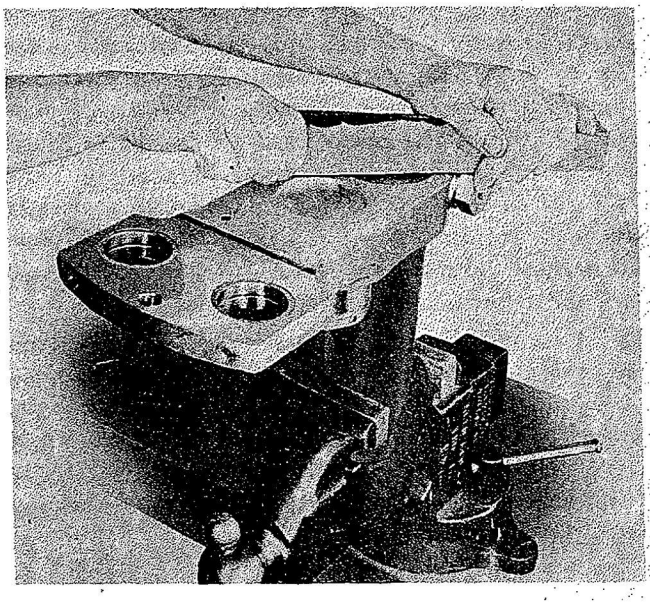

Figure 166—Polishing Crankshaft Rear End Adjacent to Crankpin Hole

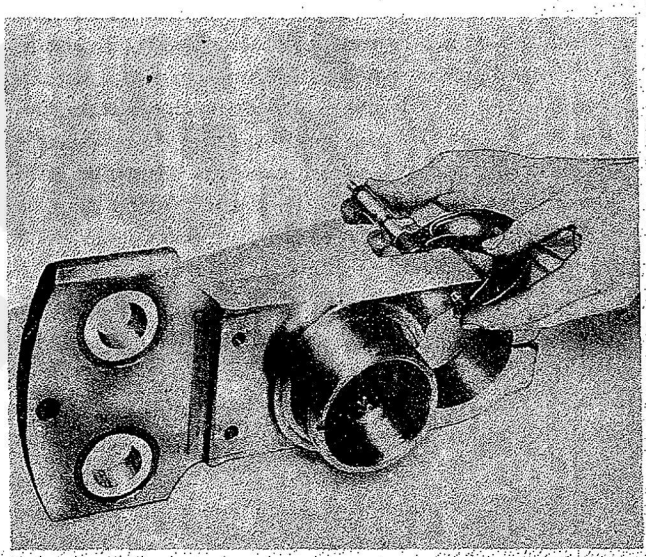

Figure 167—Measuring Width of Crankshaft Rear

in the crankcheek extension. Use plug (Tool No. 83525), and collar (Tool No. 800512). It is advisable to leave the bushing bearing partly in the crankcheek extension in order to preserve the proper alignment of the oil passages. Clean the lubrication holes thoroughly. Press the bushing back into place.

e. If replacement of the crankshaft rear end bushing bearings is found to be necessary, remove the bearings in the same manner as previously described for the crankshaft front end bushings, except use plug (Tool No. 83525) and collar (Tool No. 800512). Remove

burrs from the bearing hole in the crankshaft and smooth the inside diameter of the hole using crocus cloth and gasoline. Check the inside diameter of the bearing hole and the outside diameter of the new bearing to insure that the proper fit will be obtained. Refer to the Table of Limits in Section XII. When the rear counterweight bushings are worn, pitted or galled, but are otherwise satisfactory for continued service, they may be rotated 90° and reinstalled without further repair.

f. Place the crankshaft on base (Tool No. 83523) on an arbor press table, and press in the new bearing using plug (Tool No. 83525) and collar (Tool No. 800512). Install the collar on the plug so that the end of the collar marked "THIS END FOR INSTALLING" is inserted in the bearing. This insures that the bearing will be installed to the proper depth.

CAUTION

Do not lubricate these bearings with AN-C-53.

g. If replacement of the crankshaft rear counterweight bushings is found to be necessary, remove the bushings in the same manner as previously described for the crankshaft front counterweight bushings, except use plug (Tool No. 83525). Remove burrs from the bushing hole in the counterweight and smooth the inside diameter of the hole using crocus cloth and gasoline. Check the inside diameter of the bushing hole and the outside diameter of the new bushing to insure that the proper fit will be obtained. Refer to the Table of Limits in Section XII.

h. Press in the new bushing in the same manner as previously described for crankshaft front counterweight bushings, except do not use adapter (Tool No. 84810) in connection with the stop plate when installing the rear counterweight bushings, and use plug (Tool No. 83525).

i. Refer to Par. 45, *k*, of this section for instructions on the reconditioning of the counterweight pins.

47. MASTER ROD.

a. PREFIT SILVER BEARINGS.

(1) Silver plated, loose prefit bearings will be replaced when the lead indium plating is worn to such an extent that 20 percent or more of the silver plated surface is visible, or when the bearing is excessively scratched, dented or scored. These bearings will be returned to the engine manufacturer for replating. To select a replacement bearing, measure the diameter of the crankpin and diameter of the master rod bearing bore, and select a bearing that will provide clearances within the service limits as stated in Section XII. Bearings of this type will not be reworked in any manner, and will not be installed until after the knuckle pins have been installed, as described in Section VII. Refer to the parts catalog, T.O. number AN 02-35GC-4 for a list of available undersize and oversize bearings.

b. TIGHT FIT BEARINGS.

(1) If replacement of the copper lead master rod bearing is found to be necessary, do this in accordance with the following instructions:

(2) Place the master rod on the base of the fixture (Tool No. 84815) so that the crankpin bore fits over the large boss in the center of the base and No. 6 knuckle pin hole fits over the aligning pin. The bearing splines should be facing upward. Install the top section of Tool No. 84815 and secure it in position with the nut provided for that purpose. The assembly is placed on a drill press table and the guiding hole in the tool is lined up with the reamer (Tool No. 84819) in the spindle. Ream the bearing. This operation produces a curved groove on the surface of the bearing. Replace the rod on the fixture so that No. 5 knuckle pin hole fits over the aligning pin. This changes the relative position of the bearing to the reamer. Install the top section of the tool and secure it in position. Align the guiding hole and reamer, and ream the bearing as before. Remove the master rod from the tool and install it with grooves up in a vise between brass jaws. The section of the bearing between the two grooves must be removed before the remainder of the bearing can be taken out. To remove this section, insert the chisel between the two splines above the thin section of each groove and tap the chisel with a hammer until the shoulder of the bearing is split. Repeat this process on the shoulder above the other groove. Using a brass drift and a hammer, tap down on the splines between the two cuts until the section bends and curls inside the master rod bore. Continue tapping this bearing section through the master rod bore until a strip is removed from the bearing. The bearing may then be removed by hand. If it sticks, tap it lightly with the brass drift and hammer. Extreme care should be taken in using the hammer and chisel so as not to damage the master rod.

(3) Clean the master rod bore with crocus cloth and kerosene and polish with a cloth wheel.

(4) If the master rod bore is marred by scores, scratches, or severe chafing, it must be reworked. AAF activities apply to Headquarters, Air Service Command, and Navy activities will contact the Aviation Supply Office, Philadelphia, Penn., for disposition instructions regarding this part.

(5) When installing the new bearing, the master rod should be heated up to approximately 205°C (400° F) in an oil bath for a period of at least 30 minutes. The master rod should then be placed in an arbor press and the bearing dropped in place. Insert the arbor press plug (Tool No. 84400) in the bearing and

apply a pressure on the bearing until the rod has cooled sufficiently to hold the bearing. Use adapter (Tool No. 84401) for this operation. The bearing should be pressed home so that a .001 in. feeler gage cannot be inserted between the bearing flange and the master rod shoulder. Provision has been made so that while using these tools correct alignment of the splines on the bearing will be obtained in order that the knuckle pin locking plate will be properly located when installed.

(6) Finish bore the master rod bearing in accordance with the following instructions: Install the two locating pins in the knuckle pin holes closest to the shank of the master rod. Install knuckle pins in the remaining six holes. If this procedure is followed, the bearing surface will not be distorted when the articulated rods and knuckle pins are finally assembled on the master rod.

(7) Bore out the bearing to the dimension which will provide the correct clearance. Refer to the Table of Limits in Section XII. Use fixture and tools provided under Tool No. 83432 for finish boring. Instructions for use of these tools are furnished with the set of tools.

(8) If a silver plated master rod bearing of the loose prefit type cannot be removed or installed readily by hand, it should be chilled by packing a sack of dry ice in it to accomplish the necessary shrinkage.

(9) To remove the piston pin bushing, support the rod on collar (Tool No. 801892-1) and base (Tool No. 83409). Bore the bushing to a depth of 1/8 in. using counterbore (Tool No. 801926) with pilot and nut (Tool No. 801928) and holder. Pick out the spun top end of the bushing and press out the remainder of the bushing using plug (Tool No. 801890). Remove the plug and the rod. Clean up the rod bore and remove all burrs.

(10) To install the new piston pin bushing, place the bushing on the small end of plug (Tool No. 801-890) and screw cap (Tool No. 83579) on the plug. Lubricate the outside diameter of the new bushing with castor oil. Place the piston pin end of the rod over collar (Tool No. 801892-1) and base (Tool No. 83409) and insert the large end of the plug through the bore so that it extends into the collar. Locate the split in the piston pin bushing in the extreme end of the rod at an angle of 45 deg to the center line of the rod journal. Using an arbor press, press down on the cap on the top of the plug until the cap is in contact with the rod. Remove the plug and collar.

(11) After a new piston pin bushing has been installed, the new bushing should be burnished to provide a satisfactory surface contact between the bushing and bushing bore in the rod. This is accomplished by pressing a proper size burnishing broach through the bushing by means of an arbor or hydraulic press. Burnishing broaches have a series of steps or buttons, each one of the first twelve steps or buttons .001 in. larger in diameter than the preceding one. Selective fit broaches are available under Tools No. 802402, 802403, 802404, 802405. To burnish properly newly installed piston pin bushings, proceed as follows: Try each of the above mentioned broaches in the bushing by hand and select one in which from four to seven steps or buttons enter the bushing. If less than four steps or buttons enter the bushing, the broach is too large. If more than seven steps or buttons enter the bushing, the broach is too small. Install the selected broach in an arbor or hydraulic press. Place the collar (Tool No. 801892-2) in base (Tool No. 83409) and set the base with collar on the press table. Locate the rod with the new piston pin bushing over the collar in the base and burnish the piston pin bushing using from 500 to 600 lb per sq in. pressure to force the broaching tool through the bushing.

(12) To spin piston pin bushings, insert spinning tool (Tool No. 83345) in a drill press spindle. Support the piston pin end of the rod on plug (Tool No. 83413) in base (Tool No. 83409) and spin over the end of the piston pin bushing. Reverse the rod and repeat the same operation on the other end of the bushing. The ends of the bushing should be spun over until they bottom against the chamfer machined at each end of the bore of the rod.

(13) To face the ends of piston pin bushings, insert plug (Tool No. 83413) in base (Tool No. 83409) and locate the piston pin bushing end of the rod on the plug. Install counterbore (Tool No. 83208) and pilot and nut (Tool No. 83421) in a drill press spindle. Lower the drill spindle to locate the counterbore pilot in the plug hole and face off one end of the bushing. Reverse the rod and repeat the facing operation on the other end. The ends of the bushing should be faced flush with the rod, and should run true with the bore within .002 in. full indicator reading.

(14) Finish bore the piston pin bushings to size as follows: Check the diameter of the piston pin at the piston bushing location. Refer to Table of Limits in section XII for special clearance. Adjust the

cutting tool in the boring bar using the .600 in. constant shoe with the micrometer. Using boring fixture (Tool No. 83432) finish bore the bushings to size. Form a .015 in. radius at both ends of the bushing. Remove burrs, wash in gasoline and wipe off clean. Check the finished size of the bushing bores.

(15) Scratches or galled areas in knuckle pin holes in the master rod flanges should be removed with crocus cloth. If these areas are deep and not easily removed, return the rods to the factory for inspection.

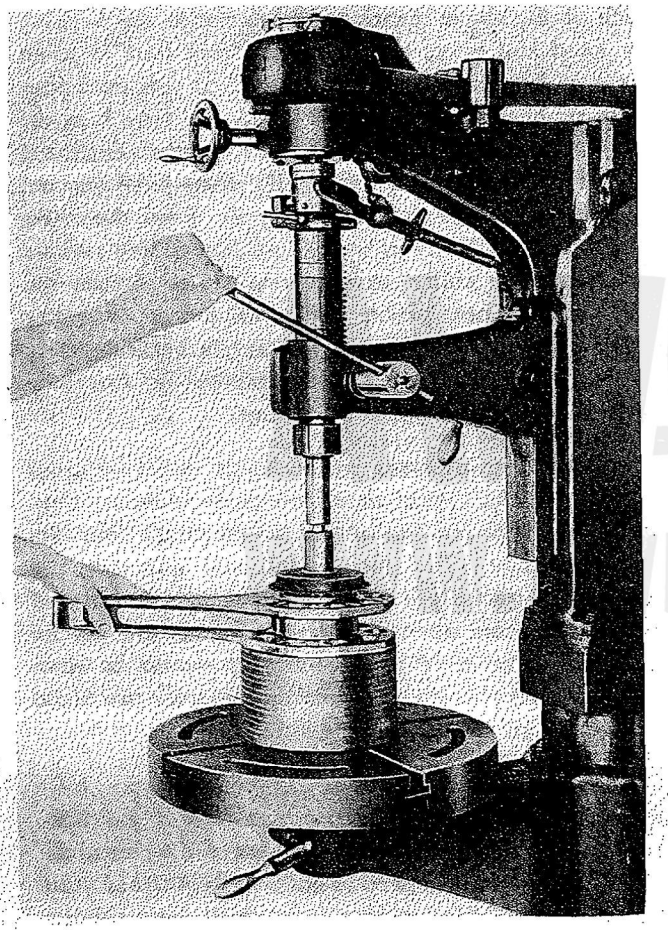

Figure 168—Polishing Master Rod Rear End

(16) Polish the rear face of the master rod large end to obtain a finish of 13 to 15 micro-inches in order to prevent mutilation and excessive wear of the master rod end seal spacer. Polish in accordance with the following instructions: Bolt the fixture (Tool No. 801628) to a drill press table approximately 1/2 in. out of line with the drill press spindle. Using belt dressing or cement, attach a piece of Aloxite No. 320 polishing cloth, or its equivalent, to the plane surface of the polishing tool (Tool No. 801547). Use a circular piece of polishing cloth approximately the same diameter as the plane surface of the polishing tool. Chuck the polishing tool in the drill press, and place the master rod on the fixture (Tool No. 801628) with the rear face of the large end up. Polish the rear end of the master rod by turning the tool at a speed of approximately 600 rpm, exerting a moderate pressure on the tool. Oscillate the master rod in the fixture while polishing. Refer to Figure 168. A worn cloth is essential for a high finish. Compare the finish obtained with the 15 micro-inch finish reference block (Tool No. 801762).

(17) The tools required for performing this polishing operation form part of the set of tools provided under Tool No. 801850.

(18) Measure the width of the master rod hub using a micrometer. Refer to Figure 169. Insure that the measured width is greater than the minimum permissible width of 3.145 in. Subtract the measured width from the original width of 3.167 in. to determine the proper oversize master rod end seal spacer to be used. This figure represents the amount of material removed from the rear face of the master rod hub. Refer to Figure 170.

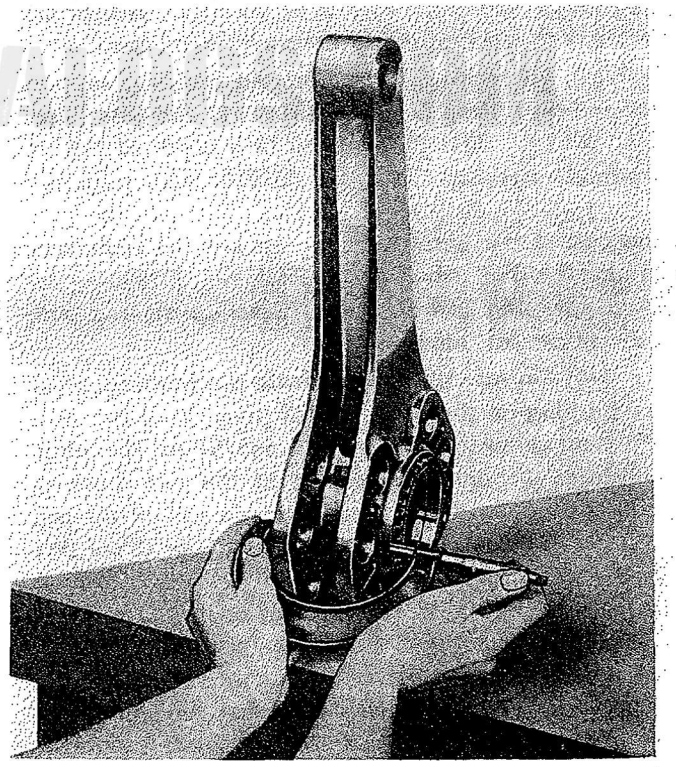

Figure 169—Measuring Width of Master Rod Hub

48. ARTICULATED RODS.

a. Piston pin bushings are replaced in the same manner as previously described for master rods. Replace knuckle pin bushings in accordance with the following instructions: Remove the knuckle pin bushings following the procedure as outlined for removal of piston pin bushings, except use base (Tool

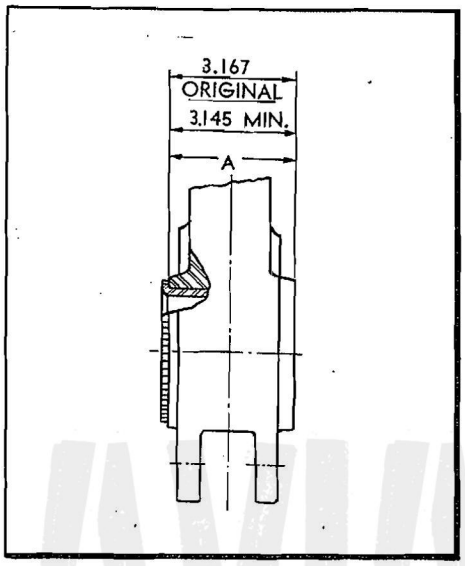

Figure 170—Master Rod Original and Minimum Widths

No. 83409), collar (Tool No. 802158-2) and counterbore (Tool No. 801930). After counterboring the spun top end of the knuckle pin bushing, press out the remainder of the bushing using plug (Tool No. 802158-1).

b. Install new knuckle pin bushings in the same manner as described for installing piston pin bushings, except use collar (Tool No. 802158-2), screw cap (Tool No. 83579) and plug (Tool No. 802158-2).

c. Burnish newly installed knuckle pin bushings following the same procedure as outlined for burnishing piston pin bushings except use base (Tool No. 83409), collar (Tool No. 802158-4), and burnishing broach (Tool No. 83420).

d. Knuckle pin bushings are spun in the same manner as described for piston pin bushings except use plug (Tool No. 83415), base (Tool No. 83409) and spinning tool (Tool No. 83373).

e. Face the knuckle pin bushings in the same manner as facing piston pin bushings, except use plug (Tool No. 83417). Face the bushing on one side to within .005 in. of the face of the rod. Reverse the rod and face the other end of the bushing in the same manner.

f. Finish bore knuckle pin bushings in the same manner as finish boring piston pin bushings with the exception that an added .0005 in. must be made for lead plating bushings. Following the boring operation, form a .015 in. radius at both ends of the bushing. Wash the assembly thoroughly and check the finish size of the bushing bores.

g. Check the alignment of the bushing bores as described in section VI, paragraph 7 *e.*

h. Lead plate the bushing if desired as described in this section, paragraph 2 *k.*

49. PROFILING CYLINDER HEAD FINS.

a. Rework cracked or broken cylinder head fins by profiling to the depth of the crack, provided the crack does not extend into the dome of the cylinder head, and provided the total amount of fin metal removed in this manner does not exceed 14 sq in. per cylinder. Fin metal may be removed from a single fin or from several fins provided the total metal removed does not exceed the limits specified. Fins on any part of the cylinder head may be reworked.

b. In profiling a fin, use a thin burring tool or grinding wheel operated on a flexible shaft. Exercise care to prevent cutting into the dome of the cylinder head, to prevent scratching adjacent fins, and to remove all sharp corners on reworked fins. Other cracks may be started from scratches or sharp corners if these are not removed. For this reason reworked areas must be smoothly profiled and blended with a minimum radius of .250 in.

c. If it is necessary to profile a fin to the outside surface of the dome of the cylinder head, perform the following inspection to insure that the crack in the fin has not extended into the dome of the cylinder: Etch locally the outside surface of the dome adjacent to the reworked fin by swabbing with a 10-20 percent caustic soda solution for seven to ten minutes. Swabbing or rubbing is necessary to accomplish continuous removal of the aluminum oxides as they are formed and to work the caustic soda into any crack that may be present. Then swab the same area with a 35-65 percent solution of nitric acid to brighten the surface and reveal any crack that may be present as a black line. If no cracks are found, wash the head thoroughly with water to remove the etching solutions. The presence

of a crack in the surface of the dome is cause for rejection of the cylinder.

d. After profiling and etching, paint the profiled area of painted cylinder head fins with lacquer or enamel. Metalized cylinder head fins require no further treatment.

50. HONING AND GRINDING CYLINDER BARRELS.

NOTE

AAF activities will refer to T. O. No. 02-1-16 for complete information concerning the grinding, honing, lapping, and reconditioning aircraft engines. Naval activities will refer to Navy General Engine Bulletin No. 24 for this information.

a. The condition of a cylinder barrel and the amount of taper, out-of-round, and wear will determine the operations to be used in reconditioning a cylinder barrel bore. If the following maximum diameter or taper limits for straight and choke bore cylinders are exceeded, the barrel should be ground to .015 in. oversize, or scrapped if the oversize limits have been exceeded. When measuring choke cylinders for taper, reference should not be made to the reduced diameter in the choke area.

Limit	*Standard Bore*	*.015 in. Oversize Bore*
Maximum diameter	6.135 in.	6.150 in.
Taper	.010 in.	.010 in.
Out-of-round	.005 in.	.005 in.

b. LAPPING.

(1) To remove surface glaze for better ring seating, cylinder barrels which are within service dimensional limits should be lapped only, in order to hold the amount of material removed from any cylinder at a minimum. Ring steps at the top of the barrel should be blended prior to lapping. Cylinders which have been reground must be lapped.

(a) Wash thoroughly with a wash gasoline to remove all grease and oil.

(b) Remove ring markings in the lower skirt area by lapping this section 10 to 15 complete strokes before lapping the full length of the barrel.

(c) Using a minimum of 100 strokes (50 in and 50 out), lap the barrel until a uniform "satin" finish is obtained. A suitable lap may be made with a .015 in. oversize dummy piston incorporating a wooden stop fastened to the piston dome on the combustion chamber side to prevent the top ring on the piston from catching at the top of the sleeve. Use standard size rings with a 45 degree x 1/32 in. chamfer on the outer edges, installing them in the grooves above the piston pin only. The piston and rings should be replaced when the clearance and wear become excessive. Apply a moderate amount of not-too-dry medium lapping compound to the piston and cylinder skirt.

(d) Use a straight reciprocating motion, rotating the piston approximately 60 degrees with each stroke, to spread the compound evenly about the barrel bore. Lapping may be done by hand or by a power driven machine incorporating a twisting action. If a Barnes honing machine is available, a lapping piston may be attached by use of adapter No. 803568. All compound must be cleaned from the machine after lapping, and care must be taken to prevent any compound from entering the coolant system.

(e) Clean the barrel thoroughly, scrubbing the bore with Varsol or with a hot soap and water solution. Clean the intake port and the intersection of the cylinder head and barrel with particular care to insure that no compound is present. Do not use an air blast for cleaning as it may pack the abrasive solidly into corners and recesses.

(f) Lapped barrels are particularly susceptible to corrosion and hence should be slushed immediately after cleaning. If cylinder barrels are to be stored even for a short period after reconditioning, they should be oiled with compound, Specification AN-C-52.

c. BLENDING RING STEPS.

(1) To prevent ring breakage, ring steps, usually found at the head end of the cylinder barrel, should be smoothed out prior to lapping or honing if the step is sharp or exceeds .005 in. in depth.

(a) For moderate localized grinding an abrasive-charged felt wheel turned by a 14,000 rpm "Thor" bantam rotary air grinder Model 0000 may be used. Wheels may be fabricated by rolling 3 in. x 1/2 in. hard piano felt disks in Le Page's glue and then in Alundum (aluminum oxide), grain size No. 180, or a comparable abrasive grit. Dry the disks in an oven and store in a dry place. Worn wheels may be dressed down in a lathe and recoated with abrasive for further use.

(b) For localized grinding to remove deep ring steps, time may be saved by using a grinding jig, Tool No. 803264, which incorporates an eccentric spindle that controls the depth of the cut of the wheel. Material is removed at the step only. Use grinding wheels 4-1/2 in. x 1-1/4 in. x 2 in. of the type recommended under paragraph 50. *e.* which have been dressed down to give a negative or "anti-choke" taper of .010 in.

in the 1-1/4 in. wheel thickness. Set the wheel to remove all material on the side of the bore where the ring step is least pronounced, being careful to avoid touching that section of the barrel with which the rings come in contact. Remove any grinding marks and the portion of the ring step that still remains on the deep side by hand stoning or with a rotary air grinder. Further conditioning of the ring step area will not be necessary prior to lapping if chatter marks and grinding ridges are avoided.

(c) As an optional method, 4-1/4 in. Micromatic Hone Corp. No. 3201 sticks may be used. Two-thirds of the stick is composed of cork in order to permit the stone to follow the contour of the bore in the choke area. Refer to *d.* in this paragraph for the proper head to be used. Adjust the stroke to confine the stones to the step area to avoid unnecessary removal of stock in the straight portion of the bore. It may be necessary to finish the blending by hand or with a rotary air grinder to avoid excessive removal of material in the choke area.

(d) Hand stoning may be used for slight ring steps, but it is a very slow and tedious operation.

d. HONING.

(1) Cylinders that evidence excessive corrosion pitting, large sharply defined hollow spots, or score marks that cannot be removed by lapping should be honed. Refer to Figure 171. If it is necessary to remove more than .005 in. of material to correct for excessive taper, out-of-round, or scoring in a cylinder barrel, grinding should be done since a hone tends to follow the contour of a worn cylinder bore. Honing should be used in moderation to produce a surface finish suitable for lapping. All barrels must be lapped after honing.

(a) In honing straight bore cylinders, use Carborundum hone stone B500MHE6 running at approximately 39 rpm and 26 to 27 strokes per minute. Micromatic honing head (Tool No. 802096) or for large quantities of barrels Tool No. 800040 may be used.

(b) In honing choke bore cylinders, the same stone (B500MHE6) may be used but must incorporate a 1/8 in. radius at the lower end of the stone to prevent digging into the barrel choke. Micromatic honing head (Tool No. 802096) is required for choke barrels. The .010 in. wear limit may be exceeded in the choke portion of a choke bore barrel up to the maximum diametral dimension permitted in the straight portion; however, as much choke as as possible should be maintained in the upper 2 in. of the barrel.

(c) A suitable honing lubricant may be made as follows: 5 parts of kerosene oil to 1 part of International 155-D-S compound by volume.

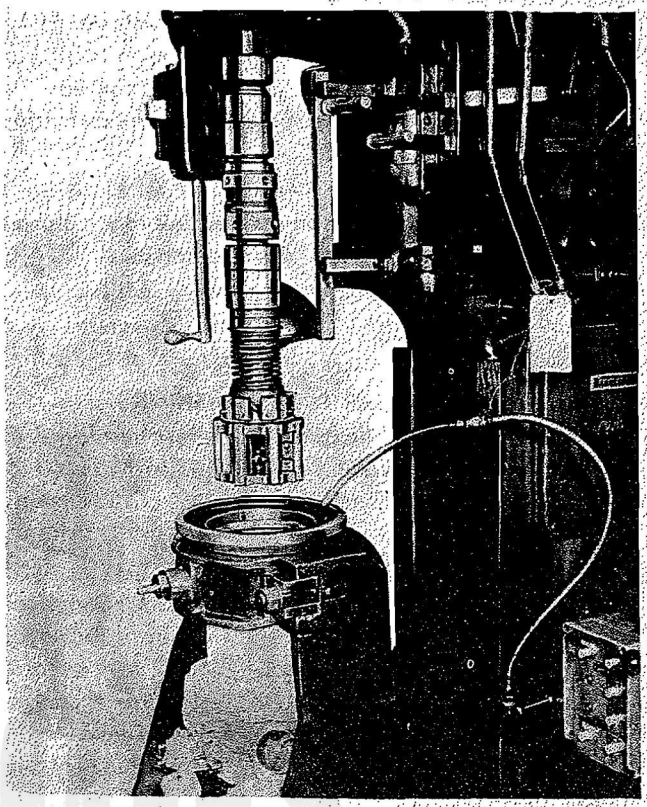

Figure 171—Honing Cylinder Bore

(d) Scored cylinder barrels that are honed must be magnetically inspected. If minute cracks are still in evidence, they must be entirely removed by grinding as they may form a source of fatigue failure.

51. INTAKE PIPE FLANGE CAP SCREW BUSHINGS.

a. Two types of intake pipe flange cap screw bushings are used in the R-1820 engine, one blind bushing and two open bushings.

b. To remove these bushings force the removing tool (Tool No. 801163) in with a hammer to a depth of about 3/8 in. and unscrew the bushing with a wrench on the tool square.

c. Bushings and taps are supplied in the following oversizes: .003, .007, and .012 in. The taps are numbered respectively (Tools No. 84840, 83639, and 84610).

d. For blind screw bushings retap the hole in the cylinder head to a depth of .46 to .59 in. while for open bushings retappings should be carried to a depth of .55 to .75 in.

e. Before heating the head try the new bushing in the hole. Select a bushing that will enter the head for about three threads when cold. Heat the cylinder in an oven for twenty minutes at 149° C (300° F). Screw in the bushing with a 9/16 in. wrench until it bottoms. Using

Figure 172 deleted in revision dated 5 October 1945.

counterbore (Tool No. 800976), holder (Tool No. 82297), and pilot (Tool No. 83641) face the bushing from 0.00 to .02 in. below the surface of the mounting flange.

f. Retap inside of bushing with tap (Tool No. 83642) to a depth of .52 to .75 in. and countersink to a diameter of .32 in. using a standard 90 deg countersink.

g. Blind bushings should be replaced with oversize blind bushings and open bushings with oversize open bushings.

52. AIR DEFLECTOR CAP SCREW BUSHINGS.

a. To replace an air deflector cap screw bushing drill out the old bushing using a size $^{25}/_{64}$ in. drill (Tool No. 801555). Remove the remaining thin shell of the bushing and retap the hole to clean up the threads in the cylinder head using a $^{7}/_{16}$-20 tap (Tool No. 800214).

b. Before heating the head try the new bushing in the hole. Select a bushing that will enter the head for about three threads when cold. Heat the cylinder in an oven to 149°C (300°F) for about twenty minutes. Coat the bushing with AN-C-53, or its equivalent, place it on a driver and install the bushing. Suitable drivers can be made from a piece of hexagonal stock with one end turned down and threaded, 1/4-28, enough to accommodate both the bushing and a lock nut. Screw in the bushing until it bottoms in the hole. Remove the driver and allow the cylinder to cool. Spotface newly installed bushings to a depth of approximately .015 in. below the head surface. Run a $^{1}/_{4}$-28 tap (Tool No. 800643) into the bushing to clean up the threads.

53. ROCKER BOLT BUSHINGS.

a. Engines equipped with rocker arm bolt bushings in the rocker box bosses, should be inspected and replacement made where necessary in the following manner: Place the puller collar (Tool No. 800099-3) between the rocker box bushings with the large end over the shoulder of the bushing to be removed. Insert the puller arbor (Tool No. 800099-1) through both bushing holes entering it from the side from which the bushing is to be removed. Place the puller bushing (Tool No. 800099-5) on the arbor, push it through the opposite bushing and locate it against the collar. Attach the puller nut (Tool No. 800099-7) to the arbor. Hold the knurled handle of the arbor and with handle (Tool No. 81403) or suitable $^{7}/_{8}$ in. wrench, screw the nut on the arbor and remove the bushing. Remove the nut and bushing from the arbor. Remove the arbor, collar, and old bushing from the rocker box.

b. Remove the bushing from the opposite side in the manner just described, except reverse the position of the tools in the rocker box and in addition insert sleeve (Tool No. 800099-8) in the hole from which the first bushing was removed. Remove the bushing. Remove the puller tools.

c. Remove burrs or nicks from the rocker box bushing holes and finished surfaces.

d. Check the outside diameter of the new bushing and the inside diameter of the rocker box holes to obtain the correct shrink fit. Refer to the Table of Limits in Section XII.

e. To install the first of the two rocker box bushings, heat the cylinder in an oven to 121° C (250° F). If a heating oven is not available, the rocker bosses may be heated locally.

f. Insert the installing collar (Tool No. 800099-9) in the new bushing and place in position between the rocker box bosses. Install the locating washer (Tool No. 800099-10) in position on the arbor (Tool No. 800099-1) so that the spherical face of the washer will contact the spherical seat on the rocker box when the arbor is in position in the bushing holes.

g. Insert the arbor with washer through both rocker box bushing holes, starting from the side in which the bushing is to be installed. Place the new bushing and collar on the arbor as it is pushed through. Place the sleeve (Tool No. 800099-8) and bushing (Tool No. 800099-5) over the end of the arbor and locate them in place. Attach the puller nut (Tool No. 800099-7) on the arbor threads, tightening it until the bushing is in place. Remove the installing tools.

h. Install the bushing in the opposite side in the same manner and with the same tools described above, except that the tools are installed from the opposite side of the rocker box and the sleeve (Tool No. 800099-8) is omitted.

i. Line ream the bushings by hand using reamer (Tool No. 800108) and check the finished hole with plug gage (Tool No. 800111). To avoid scoring the holes do not back the reamer out of the holes.

j. The fit between the rocker arm bearing and rocker box bushings is obtained by spotfacing the bushing shoulders. Correct alignment at this point is important, therefore the following instructions should be carefully observed.

k. Place the spotface cutter (Tool No. 800106-2) between the bushing shoulders. Install the washer (Tool No. 800099-10) on the turning bar (Tool No. 800106-11). Insert the bar with washer through the bushing to be faced and slide the cutter in place on the bar. Before securing the cutter to the turning bar, be sure that the

washer is installed with the spherical face contacting the spherical seat on the rocker box. Lock the cutter to the bar by means of the set screw in the cutter. Place the locating plate (Tool No. 800100-1) against the shoulder of the bushing to be faced and the copper shim (Tool No. 800100-2) between the locating plate and the cutter. The copper shim is used to protect the cutting edges of the cutter. Press the cutter against the shim with only sufficient pressure to hold the locating plate in place. Insert the locating plug (Tool No. 800104, exhaust) or (Tool No. 800102, intake) in the proper valve guide hole and determine the amount of material to be removed from the bushing shoulder by inserting a feeler gage between the "GO" diameter of the locating plug and the end of the locating plate. The bushing should be spotfaced until a .010 in. feeler gage enters freely at this point. Recheck this clearance using the "NO GO" diameter of the locating plug. The .010 in. feeler gage must not enter when this check is made.

l. Spotface the opposite bushing in the same manner and with the tools previously described, except that the tools are installed in the reverse position in the rocker box. The locating plate and feeler gage are not used when spotfacing the opposite bushing. Spotface the bushing shoulder to obtain the proper distance between the bushing shoulders. Check this distance with the "GO" and "NO GO" gage.

m. It is not necessary to remove the cutting tool from the turning bar when checking the progress of the facing operation. To make this check, center the tool between the bushings and slide the "GO" and "NO GO" gage over the cutting tool.

n. After the bushings have been properly refaced, remove the refacing tools.

54. SPARK PLUG INSERTS.

a. To replace a spark plug insert mount the cylinder in the drill press fixture (Tool No. 82955) and adjust the fixture cradle so that the insert is square with the drill press. Use counterbore (Tool No. 82776) with holder (Tool No. 81362) and pilot and nut (Tool No. 81363) to remove 45 deg shoulder from the outer face of the insert. Use counterbore cutter (Tool No. 81359) with the same holder and pilot and bore out the insert. Break out the shell that remains and remove the pieces of the old locking pins.

b. If the insert has been removed without damaging the threads in the head, tap the hole using standard tap (Tool No. 81356) to remove any small nicks and clean the threads. Select a standard insert that will allow the correct drive fit and screw it on the installation tool (Tool No. 81328). Coat the threads of the insert with Specification 2-86 or its equivalent, and screw it into the cylinder head until the shoulder on the insert is bottomed against the surface of the cylinder. Remove the tool. This operation is performed with the head and insert both at normal room temperature.

c. Locate the lock pin drill jig (Tool No. 81323) so that the new holes will be drilled midway between the old lock pin locations. Drill the lock pin holes $^{15}/_{32}$ in. + 1/32 in. −0 in. deep with a No. 31 (.120 in.) drill. Remove the drill jig and drive in the pins. The pins must bottom in the holes and be flush with or extended above the surface of the insert shoulder.

d. Spotface the insert using the spotface cutter (Tool No. 81360) with holder (Tool No. 83047) and pilot (Tool No. 83049) to a depth sufficient to clean up the face. Remove approximately .010 in.

e. Back spotface the inner face of the insert a sufficient amount to blend the end of the insert into the radius of the cylinder dome and chamfer the thread end using cutter (Tool No. 82793), with pilot (Tool No. 82794) and collar (Tool No. 82796).

f. Place the spark plug hole tap (Tool No. 81355) in a tap wrench and install the tapping bushing (Tool No. 81358) over the tap. Run the tap through the insert. Remove tap and clean the threads. Oversize spark plug inserts are installed in the same manner as previously described except that the threads in the cylinder head are tapped for .015 in. oversize with tap (Tool No. 81357) and for .030 in. with tap (Tool No. 82567).

55. REFACING EXHAUST VALVE SEATS.

a. Steel exhaust valve seat inserts will be ground when they are pitted, burned, not concentric with the valve guide, or when a new seat insert has been installed. An exhaust valve seat insert which is burned, excessively pitted, or eccentric with the valve guide in excess of the limits given below will be replaced. When the insert has been reground in previous overhauls so that the smaller diameter of the seat is within 1/32 in. from the recess in the cylinder head, and satisfactory valve clearances can no longer be obtained, the insert will be replaced. Carefully examine the condition of the seat insert after the cylinder has been cleaned, to determine the necessity of grinding or replacing the insert.

b. Check the valve seat insert for concentricity with the valve guide. Insert the exhaust valve seat bluing and limit gage (Tool No. 803920) in the valve guide. Measure the clearance between the face of the gage and the seat using a feeler gage. When feeler stock of more than .0075 in. can be inserted between the face of the gage and the seat at any point, the insert must be replaced. When an exhaust valve guide must be replaced because of an excessively

worn or bell mouthed condition, replace the guide before attempting to measure the concentricity of the seat. A guide that is excessively bell mouthed or worn will not permit an accurate measurement to be made.

c. When the condition of the valve seat is such that regrinding is necessary, or when a new insert has been installed, grind the seat in accordance with the following instructions.

d. Assemble the grinding wheel (Tool No. 800606) to the pilot, and secure it with the pilot washer and nut. When the grinding wheel is to be driven by a flexible shaft having a 1/4 in. collet use the pilot (Tool No. 83767). When a 5/16 in. collet is used, use the pilot (Tool No. 800642). Set the pilot and wheel between centers in a lathe and dress the outside diameter of the wheel flat and parallel to a diameter of 3-5/32 in., using a diamond pointed dressing tool. Remove the pilot and grinding wheel from the lathe centers, but do not disassemble the tools.

e. Install the bluing and limit gage between the lathe centers. Adjust the compound rest to the face angle of the gage, using a dial indicator. Remove the gage and indicator, reinstall the pilot and grinding wheel between the lathe centers and reinstall the dressing tool in the tool post. Ensure that point of the dressing tool is at exactly the same height at which the dial indicator was set. Dress the grinding wheel to the required angle, holding the inner diameter of the tapered face of the wheel to a maximum of 2-7/16 in.

f. Install the cylinder on the holding fixture (Tool No. 803628), using the adapter (Tool No. 803630) and the fixture plugs (Tool No. 803631). Install the pilot bushing in the valve guide from the rocker box end of the guide. Three sizes of pilot bushings are available, in order to provide a selective fit of the pilot bushing in the guide. They are: Tool No. 83768, Selective Fit No. 1, Tool No. 83769, Selective Fit No. 2, and Tool No. 83770, Selective Fit No. 3. Lubricate the pilot bushing with vaseline, install the grinding wheel and pilot in the bushing and lock it to the shaft of a suitable driving machine. Grind the seat insert at a speed of approximately 4200 rpm. Lift the grinding wheel from the seat frequently, and use a constant flow of coolant. After grinding the seat for a short time, remove the grinding wheel and pilot and the pilot bushing, and check the angle of the seat with the bluing and limit gage. When the bluing mark is not continuous across 50 per cent of the width of the seat, it may be necessary to redress the grinding wheel.

g. After grinding, the exhaust valve seat must be at least .175 in. wide with a minimum outer diameter of 3.052 in. A line of bluing should be continuous around the entire circumference of the seat. The correct inner diameter of the seat is the inner diameter of the gaging face of the bluing and limit gage, and the correct minimum seat width is the entire width of the gage face. Coat the gage lightly with prussian blue, place the gage on the seat, and oscillate it slightly to transfer the blue from the gage to the seat. Examine the blued surfaces of the gage and the seat. To ensure that concentricity of the valve seat with the valve guide has been obtained, the line of bluing on the seat should be continuous around the entire circumference of the seat. To ensure that the seat has been ground to the correct face angle, the bluing should be continuous across at least 50 per cent of the seat in areas totaling at least half of the circumference. Exhaust valve guide and seat concentricity must be within .002 inch maximum.

h. The foregoing describes the procedure for grinding the exhaust valve seat when using portable grinding equipment where the volume of work is not particularly large. For overhaul depots where the volume of this work is much greater, other machining equipment is available which will perform this work more rapidly. Information concerning this equipment can be obtained by applying to Headquarters, Air Service Command.

56. REPLACING EXHAUST VALVE SEATS.

a. Replace any exhaust valve seat that is burned, pitted, worn or eccentric with the valve guide to such an extent that it cannot be reconditioned for further use by grinding.

b. To remove an exhaust valve seat it is necessary to bore a 1/64 in. shoulder in the cylinder head behind the valve seat insert upon which to rest the removing drift.

c. Place the cylinder holding fixture and adapter on a drill press table. Place the cylinder on the fixture adapter, and locate it on the adapter with the fixture plugs. Install the cutting tool bit (Tool No. 800209-5) in the boring bar (Tool No. 800209), using the cutter setting gage (Tool No. 801287). Insert the boring bar assembly in the valve guide, and install the pilot bushing (Tool No. 800204) over the upper end of the boring bar and into the valve guide. Set the stop collar on the boring bar to support the assembly. Align the boring bar with the drill press spindle and attach the boring bar to the chuck. Bore the cylinder head until the tool bit contacts the upper face of the steel insert. Remove the pilot bushing and the boring tools, and remove the cylinder from the fixture.

Note

When the valve guide has been removed, it will be necessary to install a dummy valve guide in the cylinder head valve guide hole in place of the pilot bushing. Eight sizes of dummy exhaust valve guides are available.

They are:

Tool No. 805074	.030 in. O.S. O.D.
Tool No. 805075	.040 in. O.S. O.D.
Tool No. 805076	.050 in. O.S. O.D.
Tool No. 805077	.060 in. O.S. O.D.
Tool No. 805078	.065 in. O.S. O.D.
Tool No. 805079	.070 in. O.S. O.D.
Tool No. 805080	.080 in. O.S. O.D.
Tool No. 805081	.090 in. O.S. O.D.

d. Place the protector (Tool No. 800462) in the cylinder barrel. Mount the cylinder in the bench stand (Tool No. 800207) and tighten the clamps. Install the pilot bushing (Tool No. 800204) in the valve guide. Pass the removing drift (Tool No. 801286) up through the exhaust valve seat insert, and drop it into position in the bored shoulder. Install the punch through the pilot bushing into the socket in the drift. Install the guard over the upper end of the plug, install the plug over the end of the punch, and drive out the seat insert. When the seat insert is too tight to remove in this manner, it may be removed by heating the cylinder head with a gas and compressed air torch (Tool No. 802622). Preheat the cylinder head uniformly for at least two minutes, concentrate the heat at the seat location and measure the temperature at the spring seat in the floor of the rocker arm housing, using the pyrometer (Tool No. 802621). Continue to heat the cylinder head until the temperature reaches 149°C (300°F), and drive out the seat insert. Allow the cylinder to cool, remove the cylinder from the stand and remove the seat removing tools.

Note

When the valve guide has been removed, it will be necessary to install one of the dummy valve guides in the cylinder head valve guide hole in place of the pilot bushing. These dummy valve guides are listed under Paragraph 56, *c*, above.

e. Measure the valve seat insert recess in the cylinder head to determine the correct oversize seat insert necessary and to determine the oversize dimension to which the seat recess must be rebored. Refer to the Parts Catalogue, Technical Order No. AN 02-35GC-4 for a list of available oversize seat inserts. Refer to the Table of Limits, Section XII of this Handbook to determine the required pinch fit of the seat insert in the cylinder head. Select the required oversize cutter from the following list.

Tool No. 800331	.010 in. O.S.
Tool No. 800332	.020 in. O.S.
Tool No. 800333	.030 in. O.S.
Tool No. 800334	.040 in. O.S.

Assemble the cutter to the pilot (Tool No. 82532) and install the pilot bushing (Tool No. 82536) in the rocker arm housing end of the valve guide. When the valve guide has been removed, install one of the dummy valve guides listed under paragraph 56, *c*, above in place of the pilot bushing. Insert the pilot and cutter through the valve guide and pilot bushing, or through the dummy valve guide when used, and assemble the jack (Tool No. 82522) over the end of the pilot. Assemble the pilot handle (Tool No. 82519) to the pilot, and lock the handle in place. Bore out the seat recess, raising the cutter by turning the jack handle. Exercise care to obtain a smooth surface at the bottom of the recess. Remove the tools from the cylinder, and check the diameter of the recess with a micrometer. Remove the cylinder from the fixture.

f. Select the correct oversize seat insert, and assemble it to the exhaust valve seat insert installing tool (Tool No. 800356). Immerse the seat insert and installing tool in a solution of dry ice and alcohol, or dry ice and gasoline for 20 minutes. Place the cylinder in a flameless oven and heat it for one hour at a temperature of 316°C (600°F). Remove the cylinder from the oven, and remove the seat insert and installing tool from the cooling solution. Install the seat insert in the cylinder head seat recess, using the installing tool handle (Tool No. 81174). Assemble the puller (Tool No. 81171) to the end of the installing tool and pull the seat insert into place. Allow the cylinder to cool before removing the installing tools. Ensure that the seat insert is correctly bottomed by attempting to insert .002 in. feeler stock between the insert and the cylinder head. Exhaust valve guide and seat concentricity must be within .002 inch maximum.

g. Grind the exhaust valve seat insert according to the procedure outlined in paragraph 55.

57. REFACING AND REPLACING INTAKE VALVE SEAT INSERTS.

a. For refacing and replacing intake valve seat inserts follow the procedure as outlined for the exhaust valve seat inserts in paragraph 55 and paragraph 56. The same tools are used for the intake valve seat inserts as were used for the exhaust valve seat inserts, with the following exceptions:

800245	Bushing—Intake valve seat grinding wheel, pilot. Selective fit No. 1, .562 in. O.D.
800246	Bushing—Intake valve seat grinding wheel, pilot. Selective fit No. 2, .564 in. O.D.
800247	Bushing—Intake valve seat grinding wheel, pilot. Selective fit No. 3, .566 in. O.D.
800204	Bushing—Intake valve seat removing tool, pilot
801947	Drift—Intake valve seat insert removing
805087	Dummy Guide—Intake valve, .7176 in. O.D.

805088 Dummy Guide—Intake valve, .7226 in. O.D.
805089 Dummy Guide—Intake valve, .7276 in. O.D.
805090 Dummy Guide—Intake valve, .7376 in. O.D.
805091 Dummy Guide—Intake valve, .7476 in. O.D.
803919 Gage—Valve seat insert bluing and limit, intake
801948 Gage—Intake valve seat recess boring tool setting
800354 Installing Tool—Intake valve seat
800188 Pilot, Washer and Nut—Intake valve seat grinding (For use with a flexible driving shaft having a 1/4 in. collet)
800653 Pilot, Washer and Nut—Intake valve seat grinding (For use with a flexible driving shaft having a 5/16 in. collet)

58. VALVE GUIDES.

a. When the valve guides do not require replacement, clean the bores with crocus cloth and gasoline.

b. To replace a guide mount the cylinder in the cylinder reconditioning drill press fixture (Tool No. 803628), used in conjunction with the adapter (Tool No. 803630) and the fixture plugs (Tool No. 803631). Align the valve guide with the drill press spindle and assemble the correct drill to the chuck. Use the intake valve guide removing drill (Tool No. 802675) or the exhaust valve guide removing drill (Tool No. 802674) for the corresponding valve guide. Drill the guide to a point immediately below the shoulder, exercising extreme care to avoid cutting into the cylinder head. Insert the correct punch in the drilled guide. Use the intake valve guide removing punch (Tool No. 802841) or the exhaust valve guide removing punch (Tool No. 802575) for the corresponding guide. Strike the punch a sharp blow with a hammer to drive out the remaining portion of the guide.

c. Measure the diameter of the valve guide hole in the cylinder head. Exhaust valve guides are available in .090 inch oversize O.D. only. When guide replacement is required the .090 inch oversize valve guide will be reworked to the appropriate oversize required. To obtain the correct pinch fit, refer to item 16 in Table of Limits, Section XII. Select a reamer and corresponding gage from the following list:

Intake Valve Guide Reamers and Plug Gages

Reamer	Oversize	Gage
805173	.005 in.	800346
805174	.010 in.	800347
805175	.020 in.	800348
805176	.030 in.	800349

Exhaust Valve Guide Reamers and Plug Gages

Reamer	Oversize	Gage
805168	.005 in.	82755
805166	.010 in.	80431
805167	.020 in.	80852
805164	.030 in.	81473
805165	.040 in.	81475
805160	.050 in.	801387
805161	.060 in.	801388
805163	.065 in.	81477
805162	.070 in.	801389
805191	.080 in.	804926
805022	.090 in.	804927

d. To bore and ream the cylinder head valve guide hole to the correct oversize dimension, install the expansion plug and adapter in the valve seat insert. Insert the required dummy valve guide in the guide hole. See paragraph 56 and paragraph 57 for lists of the available dummy intake and exhaust valve guides. Install the correct expansion plug on the expansion plug adapter (Tool No. 802604). Use the intake valve seat insert expansion plug (Tool No. 802603) or the exhaust valve seat insert expansion plug (Tool No. 802599) for the corresponding seat insert. Install the expansion plug assembly in the seat insert, using the expansion plug installing tool (Tool No. 802605. Pull the expansion plug into the seat insert by turning the lower handle of the installing tool, and expand the expansion plug in the seat insert by turning the upper handle of the installing tool. Remove the installing tool and the dummy valve guide.

e. Place the reconditioning fixture on the drill press table, together with the adapter and the fixture plugs. Clamp the cylinder to the fixture adapter. Install the reamer pilot bushing (Tool No. 802606) in the expansion plug adapter. Place the aligning tool plate and aligning tool (Tool No. 803796) on the rocker arm housing cover studs, and insert the aligning bar through the aligning tool, cylinder head and the reamer pilot bushing. Clamp the aligning tool plate to the rocker arm housing, using three engine nuts. Remove the aligning bar, which must be entirely free in the aligning tool and in the pilot bushing, and remove the aligning tool from the aligning plate.

f. Set the correct tool bit in the boring bar (Tool No. 802625) for a diameter .005 in. less than the size of the selected reamer, using a micrometer. Use the intake valve guide hole tool bit (Tool No. 805157) or the exhaust valve guide hole tool bit (Tool No. 805156) for the corresponding valve guide hole. Place a No. 3 Magic Chuck in the drill press spindle. Slip the collet (Tool No. 802956) over the boring bar, and assemble the bar and collet to the drill press chuck. Set the stop on the

boring bar to prevent the cutting tool from contacting the pilot bushing, and bore out the cylinder hole. Replace the boring bar with the reamer selected, set the stop on the drill press spindle, and ream the cylinder head hole. Check the reamed hole with the corresponding plug gage. Countersink the rocker arm housing end of the reamed hole to obtain a 3.64 in. by 45° chamfer, using the countersink cutter, (Tool No. 802184). Remove the tools from the cylinder head and remove the cylinder from the fixture.

g. To install the valve guide place it on the correct installing arbor, and immerse the guide and arbor in a solution of dry ice and alcohol, or dry ice and gasoline, for 20 minutes. Use the intake valve guide installing arbor (Tool No. 800573), or the exhaust valve guide installing arbor (Tool No. 82125) for the corresponding guide. Insert the protector (Tool No. 803093) to the top of the cylinder barrel, and place the cylinder on the holder (Tool No. 803094). Ignite the compressed air and gas torch (Tool No. 802622) and preheat the cylinder head uniformly for at least two minutes, by slowly revolving the cylinder under the torch. Concentrate the torch flame at the guide location, and measure the cylinder heat temperature at the spring seat in the floor of the rocker arm housing. Continue to heat the cylinder head until the temperature has been increased to between 232°C (450°F) and 260°C (500°F). When installing the larger oversizes of the valve guides, heat the cylinder head to the 260°C (500°F) temperature. Install the valve guide, allow the cylinder head to cool sufficiently to grip the guide, and strike the arbor a sharp blow with a hammer to ensure that the guide has correctly seated. Allow the cylinder head to cool, and check the installation by attempting to pass .0015 in. feeler gage stock between the shoulder of the guide and the floor of the rocker arm housing. Remove the cylinder from the holder and remove the protector.

Note

Inspect the valve seats immediately following the installation of the guide. When a valve seat is found to have fallen more than .002 in. but less than .015 in. from the shoulder at the top of the seat recess, reheat the cylinder head to approximately 260°C (500°F) and tap the seat until it bottoms in the seat recess. When the seat has fallen more than .015 in. the pinch fit is no longer considered to be satisfactory and a new seat must be installed.

h. To ream the valve guide, install the cylinder on the fixture (Tool No. 803628) using the adapter (Tool No. 803630) and the fixture plugs (Tool No. 803631), and clamp the cylinder to the fixture. Install the expansion plug, expansion plug adapter and the reamer pilot bushing (Tool No. 802607) in the valve seat insert, as outlined in Par. 58, *d*, above. Install the aligning tool, aligning tool plate and the aligning bar as outlined in Par. 58, *e*, above. Clamp the aligning tool plate to the rocker arm housing cover studs with three engine nuts, ensuring that the aligning bar is a free fit, and does not bind in the aligning tool, the valve guide or the reamer pilot bushing. Align the cylinder to the drill press spindle, and clamp the holding fixture to the drill press table. Remove the aligning bar. Install a No. 3 magic chuck on the drill press spindle and install the collet (Tool No. 802956) on the correct reamer. Use the intake valve guide valve stem hole reamer (Tool No. 804581) or the exhaust valve guide valve stem hole reamer (Tool No. 804582) for the corresponding valve guide. Set the stop on the drill press spindle to avoid cutting into the reamer pilot bushing, and ream the valve guide. Check the reamed hole with the correct plug gage, using the intake guide plug gage, (Tool No. 800345) or the exhaust valve guide plug gage (Tool No. 82641) for the corresponding guide. Remove the reamer and collet from the drill press chuck, and remove the reamer pilot bushing, and the expansion and adapter from the valve seat insert.

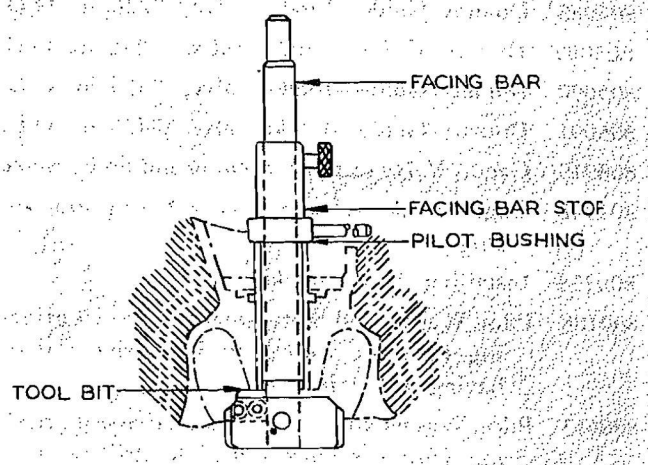

Figure 173—Back Spotfacing the Lower End of the Exhaust Valve Guide and the Face of the Guide Supporting Boss

i. The lower end of the exhaust valve guide and the face of the cylinder head exhaust guide supporting boss must be machined flush with each other to reduce the possibility of these parts being burned by the exhaust gases. Install the back spotfacing cutter (Tool No. 802-888) in the holder of the spotfacing bar (Tool No. 804-360). Install the pilot bushing (Tool No. 804361) in the

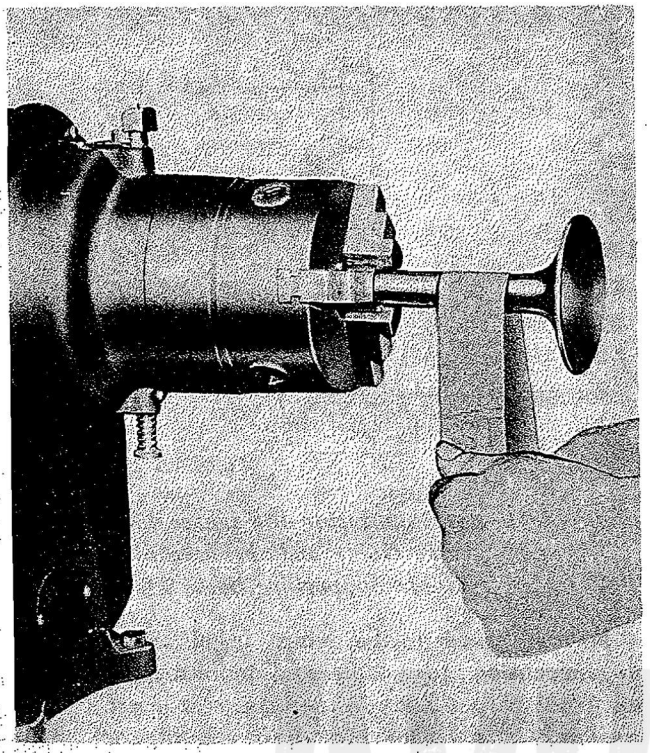

Figure 174—Polishing Valve Stems

exhaust valve guide. Insert the spotfacing bar and cutter through the pilot bushing from the combustion chamber, and secure it by installing and tightening the spotfacing bar stop collar. Refer to Figure 173 for a diagram of the back spotfacing tools in location in the cylinder head. Assemble the spotfacing bar to the drill press chuck, and back spotface the valve guide and the lower end of the guide supporting boss. Remove only sufficient metal from the cylinder head to obtain a smooth, unbroken surface. Remove the drill press chuck from the facing bar, remove the facing bar stop collar and remove the facing bar and cutter from the cylinder. Remove the pilot bushing from the valve guide, and measure the distance from the lower end of the exhaust valve guide to the outer valve spring seat in the floor of the rocker arm housing, using the back spotfacing limit gage (Tool No. 803303). When the pin is flush with the top surface of the groove in the gage, the maximum limit for the back spotfacing operation has been reached.

59. VALVES.

a. Stone burrs or nicks from the valve spring washers and from the valve split locks.

b. If a valve face is pitted or warped, reface it in a valve refacing machine. Remove no more metal than is absolutely necessary to true up the face.

c. When exhaust valves are refaced a sharp edge sometimes remains on the outside diameter of the face. After regrinding valves, it is recommended that this edge be checked, and if necessary, it should be broken to a .010 in. minimum radius with a hand stone while the valve is rotating in the refacing machine.

d. Valve stems become glazed, discolored and in some cases coated with carbon during engine operation. These surfaces should be polished by the use of a stitched cloth type buffing wheel which will remove the carbon deposits and discoloration but will not disturb the glaze, or by the use of crocus cloth and gasoline with the valve stem locked in a rotating lathe chuck as in Figure 174. Exhaust valves have nitrided stems and stellite faces. Do not attempt to remove score marks or pitting which require removal of more than .005 in. metal from the stem.

e. Light scores or pit marks may be removed by grinding and polishing.

f. Standard exhaust valve stems are .6820 to .6825 in. in diameter. The minimum diameter to which the neck of the exhaust valve stem may be reground is .667 in. The neck diameter must blend with the stem diameter at a point no less than four inches from the valve tip. The minimum diameter to which the valve stem may be reground is .677 in., or .005 in. less than the basic diameter of .682 to .6825 in. If the pits or score marks cannot be removed by regrinding to the above dimensions, replace the valve.

g. If grinding facilities are not available, valves will be properly prepared for storage, tagged and set aside. AAF activities will submit an Unsatisfactory Report to the Headquarters, Air Service Command, and the Navy activities will contact the Aviation Supply Office, Philadelphia, Penn., for disposition instruction.

h. Polish the valve head with crocus cloth and gasoline to remove all scratches.

i. Stone light scores and remove all burrs from the valve lock recess.

j. Grind the faces of valves to an angle of 44° 0′ to 44° 15′.

k. Grind valve faces as follows: Set up the valve refacing machine and accurately grind the valve face to the required angle. Use the exhaust valve face angle checking blue gage (Tool No. 802687) and the intake valve face angle checking blue gage (Tool No. 800503) for the corresponding valve. Coat the seat angle on the blue gage lightly with prussian blue, insert the valve in the gage, rotate it so that the blue will be transferred from the gage to the valve face, then remove and inspect the valve face for correct angle. The valve face angle may only be considered satisfactory when contact around the entire circumference of the valve face is obtained.

l. Check the tightness between the valve face and valve seats as follows: Assemble the valves in the cylinder, being sure the faces of the valve and valve seat are free of dust or dirt. Insert dummy or other suitable spark plugs in the spark plug inserts. Place the cylinder on a bench with the skirt of the cylinder up, pour enough unleaded gasoline into the cylinder to cover the heads of the valves and with suitable plugs inserted in the exhaust and intake ports apply an air pressure of 5 to 8 lb per sq in. in each valve port successively. If no air bubbles are noted in the gasoline, the valves and valve seats are satisfactory. If air bubbles are present, disassemble the defective valve from the cylinder and regrind the valve face and valve seat, reassemble the valve in the cylinder and repeat the test. If a valve does not air test satisfactorily after regrinding, it is permissible to lightly lap the valve into the seat, provided the differential seat angles are not materially changed and the width of the lapped valve face and valve seat do not exceed 1/16 in.

m. Before attempting to perform a lapping operation, thoroughly inspect the grinding equipment for defects, the grinding wheels for correct angles and the valve seat for concentricity with the valve guide.

n. To perform the lapping operation apply a small amount of 3 M Oil Mixed Lapping Compound, or its equivalent, to the valve face at the large diameter of the angle and spread it evenly around the circumference of the seat. Do not get any compound on the valve stem. Insert the valve in its proper location in the cylinder and attach lapping handle to the valve stem.

o. Apply a light pressure on the lapping handle and lightly lap the valve and seat using an oscillating motion. Following the lapping operation wash the valve and cylinder thoroughly with unleaded gasoline, blow dry with compressed air and retest for leakage.

p. Valve tips are of uniform hardness, therefore, it is permissible to remove grooves or wear caused by the rocker arm roller, provided the amount of metal to be removed does not exceed the limit of tip refacing as determined by the valve limit gage. Break the sharp edge with a hand stone after grinding the tip. Recondition intake valves in the same manner as described for exhaust valves wherever the operations are applicable.

60. PISTONS AND PISTON RINGS.

a. When the piston ring lands are worn sufficiently to require truing up, the ring grooves may be machined and oversize width rings installed. Both wedge type and plain piston rings of .004 and .010 inch oversize width are available for replacement in pistons used in Army engines. Wedge type rings of .010 inch oversize width are supplied for pistons used in Navy engines. When clearances within the service limits will result from their use, standard size wedge type and plain rings will be used on both Army and Navy engines.

b. Ensure that the face plate of the lathe to be used runs true within .0005 in. full indicator reading. Ensure that the top surface of the lathe compound rest is parallel and square with the lathe bed, resurfacing the compound rest when necessary. Ensure that the gibs on the lathe carriage, cross feed and compound rest are tightened securely to prevent the cutting tool from being drawn into the piston groove.

c. Clamp the piston reconditioning fixture (Tool No. 801830) on the lathe face plate, and indicate the horizontal surfaces of the piston retaining shoulders of the fixture to run true within .0005 inch full indicator reading.

d. When the ring grooves to be machined are of wedge shaped cross section, mount the wedge shaped ring groove cutting tool (Tool No. 801049) in the lathe tool post. Ensure that tool post used is of the double clamping screw type. The single clamp screw type is not sufficiently rigid for this use. Use parallel blocks to elevate the cutting tool so that the point of the tool is at the exact height of the lathe spindle centerline. Place the cutting tool checking gage (Tool No. 803720) flat against the face of the lathe fixture, and accurately align the cutting edges of the tool with groove in the checking gage. Tighten the two tool post clamping screws securely.

e. Insert the draw in rod through the fixture and lathe face plate, and secure it with the nut and washer. Mount the piston on the fixture, insert the dummy piston pin through the piston and eye of the draw in rod and tighten the draw in rod nut. Indicate the land between the second and third ring grooves from the top of the piston to run true within .0005 in. full indicator reading. Indicate one side of the second ring groove to run true within the same limit, and shim the piston with paper between the piston and fixture when necessary to achieve the desired minimum run-out.

f. Before introducing the cutting tool in the groove, remove the carbon from the ring groove and check the groove with the maximum limit gage (Tool No. 801-783). When the gage points can be passed through a wedge shaped ring groove, the piston is no longer suitable for service use. When the piston is satisfactory for further use, break the glazed surfaces of the ring groove with a fine grade of emery paper. When this is not done, the fine cutting edge of the grooving tool will be quickly destroyed. Centralize the cutting tool in the ring groove, and advance it as far as possible without touching the bottom of the groove. Set the micrometer cross feed to

zero at this point, in order to establish a maximum depth of cut. Move the carriage so that the edge of the cutting tool touches the right side of the groove, and withdraw the tool from the groove. Adjust the lathe spindle speed to 125 rpm. Under no circumstances will a speed greater than 200 rpm be used. Suitable cutting oil should be used freely. Using the micrometer feed, move the carriage .001 in. to the right. Advance the tool into the piston groove until zero on the cross feed index is reached. Repeat the cutting operation until the right side of the groove presents a smooth unbroken surface. Set the feed in the same manner for the left side of the groove, and refinish this surface. Remove an equal amount of metal from both sides of the ring groove as required to accommodate the oversize width ring to be installed. Repeat this operation as required for the remaining wedge type ring grooves. Break all sharp edges to a radius of approximately 1/64 inch, using crocus cloth, and reinspect the grooves with the maximum limit snap gage.

CAUTION

The wedge type piston ring groove cutting tool will be ground on the top surface only. Check the edges of the tool after grinding, using the cutting tool checking gage, to ensure that the angle is maintained.

g. Treat the ring grooves of rectangular cross section, as required, in the same manner, using a standard cutting tool. Grind the cutting tool so that smooth fillets of 35° to 45° radius between the bottom and the sides of the ring grooves will be ensured. When the side clearance service limits are exceeded when a standard ring is installed on a piston used in a Navy engine, the piston is no longer satisfactory for service use. When the service limit for the ring side clearance is exceeded with a .010 in. oversize width ring installed in a piston used in an Army engine, that piston must also be replaced. Break all sharp edges to a radius of approximately 1/64 in., particularly at the intersections of the oil drain holes with the two ring grooves next above the piston pin bore.

h. It is recommended that piston rings be replaced at each engine overhaul. For instructions on fitting new rings in the piston, refer to Section VIII, Par. 47 of this technical order.

61. ROCKER ARMS.

a. To remove a rocker arm roller hub or pin that requires replacement, grind one end of the pin flush with the face of the fork. Be careful not to mar or remove any metal from the fork. Center punch the center of the ground end of the pin and with a suitable drill remove most of the metal that has been peened into the hole chamfer. Hold the rocker arm on a piece of stock provided with a hole large enough for the unground head of the pin to enter. Locate the arm so that the pin head is directly over the hole and drive out the pin, using a punch 15/64 in. in diameter.

b. To install a new rocker arm roller or hub select a roller hub that will fit the fork in the rocker arm from .000 to .001 in. tight. Hold the roller and hub in place in the arm and drive in the new pin until the ends extend an equal amount on each side of the rocker arm fork. Hold the rocker arm in one hand with the pin upright on an anvil. Strike the pin one hard blow with a heavy hammer first from one side, then a second blow from the opposite side. This will swell the pin to fit tight in the hub, then peen the ends of the pin with a light hammer to spread the pin metal into the chamfer in the pin hole on each side of the rocker arm fork. Rivet the ends using a rivet setter. The fork in the arm will not be closed up by riveting as the roller hub is slightly wider than the roller.

c. Remove all burrs or nicks from the screwdriver slots of the adjusting screw and dress the threads if necessary. Clean the cup with crocus cloth held on an old push rod ball end. This operation is best done by securing the crocus cloth over the push rod ball end and chucking the push rod in a lathe or drill press. If the adjusting screw is screwed into a discarded rocker arm it can easily be held against the revolving crocus cloth covered push rod ball end. After this operation clean the oil hole and remove sharp edges.

d. If the clamp screws are not to be replaced, stone the heads to remove all burrs and smooth the threads if necessary.

e. Remove any nicks or burrs on the rocker arm bolts, nuts, or outside surfaces of the spherical washers, but do not disturb the spherical seat surfaces.

62. PUSH RODS AND PUSH ROD HOUSINGS.

a. Roll push rods which are slightly bent and are to be straightened on a flat plate to determine the high spot and tap back to proper shape with a light rawhide mallet. Continue this operation on each rod until it is straight as determined by the use of V-blocks and dial indicator. Check the ball ends for tightness and tubes for cracks after straightening.

b. Clean the ball ends with crocus cloth in the same manner as described in the cleaning of the adjusting screws except that in this case a discarded adjusting screw is chucked in the lathe or drill press.

c. Do not attempt to renew push rod ball ends.

d. Remove dents from the push rod housings by tapping them out when the housing is placed on a properly fitting mandrel.

63. INTAKE PIPES.

a. Straighten intake pipes that are not too badly dented by placing the pipe on a mandrel of the proper size and shape and by hammering out the dents with a light wood or fibre mallet. Use extreme care when hammering not to reduce the wall thickness of the pipes.

b. Remove any nicks or burrs from the attaching flange with a fine file. Smooth the finished surfaces with crocus cloth.

64. AIR DEFLECTORS.

a. Straighten cylinder air deflectors which are bent or dented. Small cracks may be repaired by welding.

b. Replace any loose rivets using a rivet setter.

c. Replace any screws or nuts having damaged threads.

d. Re-enamel the intake pipes or air deflectors as necessary.

65. IGNITION WIRING MANIFOLD ASSEMBLY.

a. Repair cracks in the manifold ring by silver soldering or brazing. Dress up any damaged threads and remove all dents from the ring and outlets and replate if necessary. Remove any nicks or burrs from the magneto outlets or elbow flanges using a fine file. Replace any flexible conduits having broken braid, or coupling nuts with mutilated threads. Renew the ignition contact sleeve and spring assembly if the spring is loose or broken or if the sleeve is cracked. Replace the spark plug terminal elbows if cracked or if the coupling nuts are cracked or the threads mutilated. Stone any burrs from the edges of the coupling nuts. Clamps or brackets that are cracked or broken should be replaced. Discard the ignition wire and all rubber washers and packing.

66. ROCKER BOX FACE.

Rocker box faces which are nicked, dented, or scratched will be reworked by machining to obtain a flat, true surface. The minimum acceptable distance between the Rocker box face and the center of the Rocker box hub bolt bushing face after rework is .720 inch.

67. EXHAUST PORT FACE.

Worn or galled cylinder exhaust port faces will be reworked by machining to clean up the damaged area. The minimum acceptable dimension between the exhaust port face and the center line of the exhaust valve guide after rework is 2.700 inches.

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SECTION VIII

ASSEMBLY OF SUBASSEMBLIES

1. GENERAL.

a. The successful operation of the engine is dependent upon the attention given to every detail, not only during the inspection and repair, but also at the time the final assembly is accomplished. It should be constantly borne in mind that neglect or carelessness in the manner in which the simplest of shop operations is performed may result in failure of the engine. The following information is offered as a means of aiding operators in establishing a shop procedure which will result in greater safety and a more uniform and higher type of workmanship. Certain of this information may be elementary to many operators and their shop personnel, however, it is repeated herein in the interest of uniformity.

b. The following engine parts should not be used a second time: gaskets, packing, lock wire, cotter pins, palnuts, circlets, spring type piston pin retainers, piston rings, oil seal rings, push rod housing hoses, generator and magneto drive oil seal diaphragms and ignition wire cable.

c. Install palnuts as shown in Figure 175.

d. Great care should be taken to prevent dirt, dust, cotter pins, lock wire, nuts, washers, and any other small parts from falling inside the engine. It is advisable to keep all spark plug holes, intake pipe openings, carburetor inlet opening, and all accessory drive openings well covered until the respective part is installed in place. Suitable metal breather type plugs to fit the spark plug holes, metal plates to snap in place in the intake pipe openings, and a metal plate for the carburetor inlet opening can be made by the operator.

e. If the disassembled engine is to stand for any length of time before assembly can be completed, all steel parts should be covered with oil to prevent corrosion.

f. Completely finish each step in the process of assembling as the work progresses. Do not leave a bolt loose or nut unlocked, with the idea of coming back to it later. Detail parts, subassemblies, or partially assembled engines should always be properly covered when not being worked on.

g. Never slack off a nut in order to line up a slot in the nut with the cotterpin hole in the bolt or stud. Replace it with another nut if it cannot be tightened to line up properly within the required torque limits.

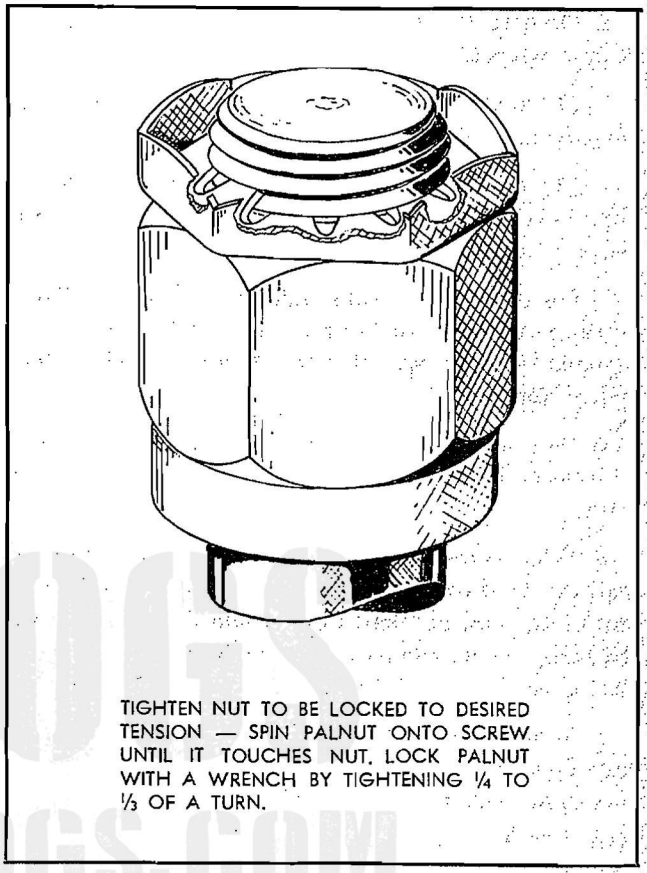

Figure 175—Method of Installing Palnuts

h. Before being assembled in the engine, all parts should be thoroughly cleaned and free from grit or dust. Wipe them with a clean, dry rag, which is free from lint. Never use cotton waste or tattered rags.

i. Remember that the engine will operate for a short period before the oil pump will start to furnish the regular supply of oil. Coat all bearing surfaces, therefore, with a good supply of engine lubricating oil before assembling. Nuts and parts which are a drive fit should likewise be oiled.

j. It is recommended that engine oil be applied freely to the pistons and rings just prior to their assembly in the engine, whether they are new or used pistons. This will improve piston ring operation and reduce wear on the piston rings during the first few hours of operation.

k. A torque indicating wrench should be used when tightening nuts during engine assembly and the tightening torque value listed in the Table of Limits, Section XII, should be applied.

l. Observe the following precautions when using a torque wrench:

(1) Make certain that no part of the wrench binds on any part of the engine.

(2) Install the wrench in such a position that the nut or cap screw may be pulled up to the required torque in one continuous motion.

(3) The torque load should be applied until the nut or cap screw has ceased to turn. This may require several seconds from the time that the indicator reaches the required torque value.

m. Steel cotter pins must be used in every case in order to insure proper safety. Brass cotter pins should never be used.

n. Select cotter pins to fit tight in the hole. Always install the head or loop end of the cotter pin to fit in the slot of the nut, not across or outside the slot, and bend the ends, one up and back over the bolt or stud end, and the other down and flat against the hexagon flat.

o. When using lock wire select a size which will fit the hole fairly tight and twist uniformly with pliers to obtain tight loops at each end. The wire should be tight so that vibration will not cause the wire to chafe and break.

2. CRANKCASE FRONT SECTION.

Before assembly of the crankcase front section reinstall all oil passage plugs.

3. PROPELLER GOVERNOR DRIVE.

a. Assemble the governor drive gear to the governor drive gear shaft. Ensure that the drive shaft used is of the latest type, which may be identified by the mounting flange thickness of .130 in. Ensure that the six attaching cap screws used are 5/16 in. in length. Install the capscrews and tighten them to the required torque value. Apply the correct tightening torque as specified for the size of cap screw used. See the Table of Limits, Section XII. Lockwire the capscrew heads in pairs.

b. Lubricate the propeller governor drive gear shaft and bushing, and install the shaft in the bushing from the interior of the crankcase front section. Install a new locking circlet on the anti-gear end of the shaft.

c. Install a new gasket and the governor substituting cover on the crankcase front section, and secure with flat washers, plain nuts, and palnuts.

4. THRUST BEARING—.666 (3:2) REDUCTION GEAR.

a. In engines provided with a .666 (3:2) reduction gear, proceed with the assembly of the crankcase front section as follows, after installation of the propeller governor drive: Place the crankcase front section on a bench, front end down. Install the thrust bearing in the thrust bearing retainer, insuring that the side of the bearing marked "PROPELLER END" is towards the front of the retainer. If the thrust bearing incorporates a split inner race, it will be necessary to install only the outer race, cage and balls, and the rear half of the inner race at this time. Tap the thrust bearing outer race lightly to insure that it is contacting the front lip of the retainer.

b. Determine the thrust bearing side clearance as follows: Place two feeler gages of equal and known thickness on the antipropeller side of the thrust bearing outer race, 180 deg apart. Install the stationary reduction gear, tapping it firmly in place against the shims. Measure the clearance between the stationary reduction gear and the crankcase front section. The difference between the measured clearance and the shim thickness is equal to the thrust bearing side clearance. Refer to the Table of Limits in Section XII.

5. STATIONARY REDUCTION GEAR—.666 (3:2) REDUCTION GEAR.

NOTE

Oversize thrust bearing spacer oil seal rings must be used in every case with a stationary reduction gear which has been ground oversize on the inside diameter. Use oversize rings corresponding to the gear inside diameter oversize.

a. Install the stationary reduction gear in position in the crankcase front section and install the pinion guard ring in position on the gear. Secure the gear and ring with flat washers, castellated nuts, and lockwire on the two studs in the interior of the crankcase front section. Install the eight stationary reduction gear attaching bolts from the interior of the front section. Insure that the head of each bolt is properly seated against the flange of the stationary reduction gear, and snap the retaining circlets in the groove in the threaded end of the bolts.

6. THRUST BEARING SPACER—.666 (3:2) REDUCTION GEAR.

a. Fit new oil seal rings in the thrust bearing spacer,

insuring that the proper ring side clearance and gap are obtained. Refer to the Table of Limits in Section XII.

b. Lubricate the thrust bearing spacer and ring assembly and the inside diameter of the stationary reduction gear, and install the spacer and ring assembly in the gear. Exercise care to insure that the rings are not damaged when installing the spacer in the gear. The end of the spacer which is provided with a lip on the inside diameter must be toward the front of the gear.

7. CRANKCASE FRONT SECTION FLANGE AND SPACER—.666 (3:2) REDUCTION GEAR.

a. If the thrust bearing is of the split inner race type, install the front half of the inner race at this time, before assembly of the front section spacer and flange.

CAUTION

Check to insure that all parts of the thrust bearing assembly bear the same serial number, if the bearing is of the split inner race type. Failure of the bearing may result from the use of mismatched halves of the split inner race, outer race, and retainer and balls.

b. Install a new gasket, the front section flange, and the aluminum spacer in position on the crankcase front section, and secure with ten flat washers and castellated nuts, using a torque indicating wrench. Refer to the Table of Limits in Section XII for the proper tightening torque to be used in tightening the nuts. Lockwire the nuts in pairs.

c. Turn the crankcase front section over on the bench front end down, locating the front section centrally over a hole five inches in diameter cut in the bench. This hole will accommodate the propeller shaft when installed. If the thrust bearing is of the split inner race type, locate assembly block (Tool No. 801560) over the hole in the bench, and invert the crankcase front section over the block. The block supports the front section on the thrust bearing inner race, which is necessary during installation of the propeller shaft when this type of bearing is used.

8. PROPELLER SHAFT AND PINIONS—.666 (3:2) REDUCTION GEAR.

a. Install the propeller shaft in holding fixture (Tool No. 803529) in order to facilitate assembly of the reduction gear drive pinions.

b. Lightly coat the threads of the pinion lock bolts with AN-C-53, or its equivalent. Coat the pinions with engine oil, and install the pinions in the pinion arm bushings. Install the lock bolts in the pinions by hand.

NOTE

The pinion lock bolts are provided with a left hand thread.

c. Engage the pinion locking tool (Tool No. 83308) with the teeth of any two adjacent pinion gears. Tighten both lock bolts to a torque value of 350 to 400 in. lb. using the torque wrench (Tool No. 84922) and the adapter (Tool No. 800562). Tighten all pinion lock bolts in this manner.

Figure 176 Deleted in Revision

d. Check the end clearance of the pinions. To do this, press the pinion back until it is in its extreme rear position. Measure the clearance between the pinion lock bolt and the rear end of the propeller shaft using a feeler gage. Refer to the Table of Limits in Section XII. Repeat this check for all pinions.

e. Select cotter pins to be used for locking the pinion bolts. Bend the flat heads of the cotter pins to an angle of approximately 45 deg, using the cotter pin bending tool (Tool No. 800375). Insert the cotter pins in the bolts so that the heads lie flat against the bottom of the recess in the bolt heads. Spread the ends of the cotter pins inside the bolts. Refer to Figure 177. Insure that the cotter pins are installed tightly to avoid

loosening during engine operation. Remove the propeller shaft from the fixture.

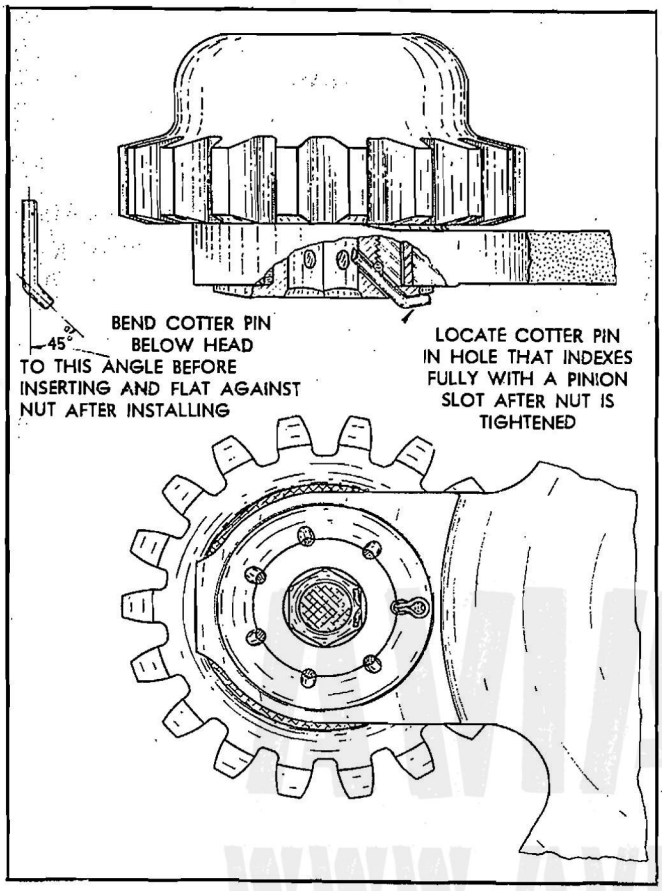

Figure 177—Cotterpinning of Reduction Gear Pinion Retaining Nut

f. Since the thrust bearing inner race is a tight fit on the propeller shaft, it is necessary to expand the thrust bearing inner race by heating before installation of the propeller shaft in the crankcase front section. This is accomplished by use of the thrust bearing heating iron (Tool No. 800310). Heat the iron in an oil bath maintained at a temperature of 177° to 205° C (350° to 400° F) for twenty minutes. With the crankcase front section placed front end down over a hole in the bench to accommodate the propeller shaft when installed, place the heating iron in the bore of the thrust bearing spacer and thrust bearing. Refer to Figure 178. Cover with a heavy cloth to prevent loss of heat from the iron. Leave the heating iron in the front section for approximately ten minutes, until the thrust bearing has expanded sufficiently to permit the propeller shaft to be installed. Remove the heating iron and install the propeller shaft immediately, meshing the pinions with the stationary reduction gear. It will be found that rotating the propeller shaft and pinion assembly slightly while pressing down into the front section will facilitate meshing these gears. Lift the front section immediately and invert it, holding the propeller shaft in position by hand, and place the assembly on a block underneath the propeller shaft.

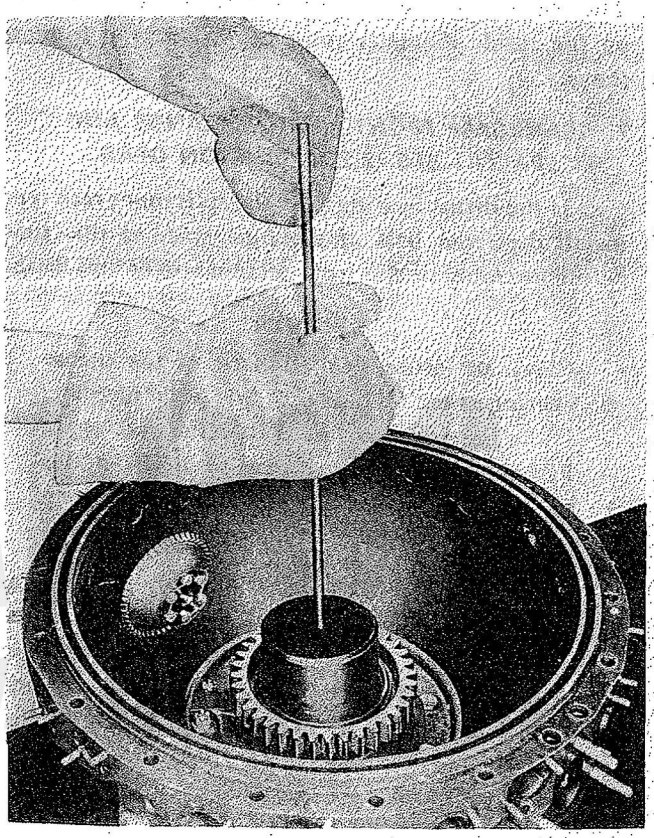

Figure 178—Heating Bore of Thrust Bearing Spacer and Thrust Bearing

9. THRUST NUT—.666 (3.2) REDUCTION GEAR.

a. Lead indium plate the thrust nut rings to a thickness of .0002 inch to .0005 inch for obtaining a satisfactory oil seal at the thrust nut location. Fit new oil seal rings in the thrust nut, insuring that the proper ring side clearance and gap are obtained. Refer to the Table of Limits in Section XII.

b. Lubricate the thrust nut and ring assembly and the inside diameter of the crankcase front section flange, and install the thrust nut and ring assembly on the propeller shaft by hand. Exercise care to insure that the rings are not damaged when screwing the thrust nut on the propeller shaft. Do not draw the thrust nut up to final tightness until final assembly.

10. PROPELLER SHAFT AND PINIONS—.5625 (16:9) REDUCTION GEAR.

a. In engines provided with a .5625 (16:9) reduction gear, the crankcase front section assembly is built up on the propeller shaft. In these engines, proceed with the assembly of the crankcase front section as follows: Install the propeller shaft in the holding fixture (Tool No. 803529) in order to facilitate assembly of the pinion carrier and pinions. Lightly coat the body of each pinion carrier attaching bolt with AN-C-53, or its equivalent. Assemble the pinion carrier to the propeller shaft using the attaching bolts and nuts. Tighten these nuts using a torque indicating wrench. Refer to Figure 179. Observe the proper torque value. Refer to the Table of Limits in Section XII. Secure the nuts with cotter pins. Insure that the cotter pins are tight after installation.

b. The pinion carrier trunnions, pinion bushings, and pinions used in .5625 (16:9) reduction geared engines are all numbered for location. Pinion bushings and pinions should be replaced on the same trunnions on which they were originally assembled. Lubricate the bushings with engine oil and insert them in their respective pinions so that the flanged end of the bushing is at the chamfered end of the inside diameter of the pinion. Install the gears and bushings on their respective trunnions. Lightly coat the threads of the pinion lock bolts with AN-G-5, or its equivalent. Install the lock bolts and nuts in the pinion carrier by hand.

NOTE

The pinion lock bolts are provided with a left hand thread.

c. Engage the pinion locking tool (Tool No. 83507) in the slots in two bolt heads to prevent the bolts from turning, and tighten the nuts using a torque indicating wrench. Refer to Figure 180. Observe the torque value specified in the Table of Limits in Section XII. Tighten all pinion lock bolt nuts in this manner.

d. Check the end movement of the pinions. To do

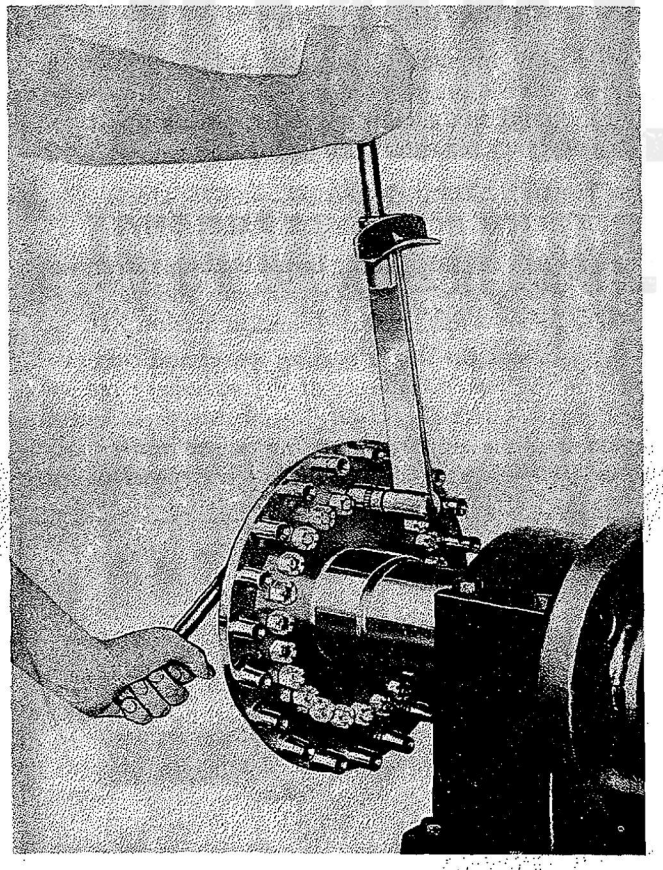

Figure 179—Tightening Pinion Carrier Attaching Nut (16:9)

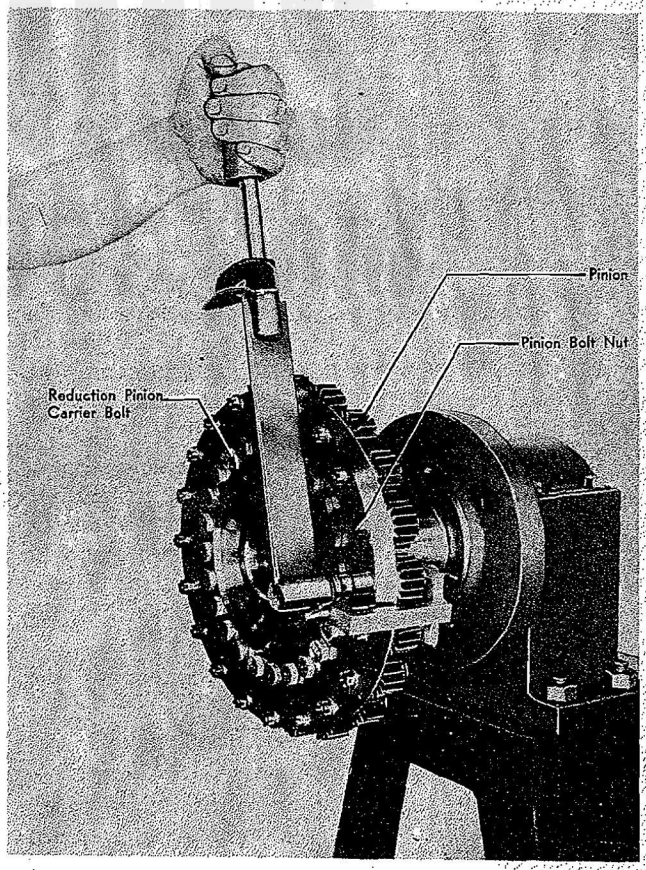

Figure 180—Tightening Pinion Lock Nut (16:9)

this, place the propeller shaft on a bench, rear end down. Measure the clearance between each pinion and its bushing, using a feeler gage. Refer to the Table of Limits. Cotterpin the lock bolt nuts securely.

10A. TEST FOR EXCESSIVE LEAKAGE OF THE PROPELLER HYDRAULIC PASSAGES.

a. Due to the possibility of excessive oil leakage of the propeller shaft oil sleeve rings between the propeller shaft oil seal sleeve and stationary reduction gear support sleeve at 600 pounds per square inch oil pressure, the following procedure will be executed:

(1) After the crankcase front section is assembled, place it on a stand. (See figure 180A.)

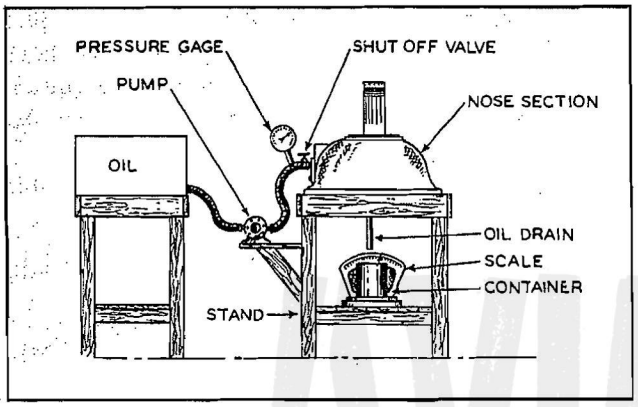

Figure 180A—Equipment for Testing Leakage of the Propeller Hydraulic Passages

(2) Fasten a test pressure plate at the governor pad location on the front section. (See figure 180B.)

(3) Tighten hose connections.

(4) Pump oil 600 pounds per square inch into the hydraulic passage for 2 minutes or longer. Use Federal Specification No. VV-O-581, grade 20 lubricating oil, 20°C plus or minus 3°C (85°F plus or minus 5°F). Rotate the shaft to assure proper fitting of the oil rings.

(5) When the nose oil leakage has become a steady flow, check the pointer on the scales, note its position on the dial, start a stop-watch. After 60 seconds stop the watch and check the pointer on the scale dial. The difference in reading on the scale dial for the 60 seconds will be the amount of oil that has leaked by the nose oil rings.

Minimum leakage permitted 1.5 pounds per minute.

Maximum leakage permitted 3.5 pounds per minute.

(6) If there is no leakage or if the weight of oil exceeds the amount of leakage allowable value (given in the preceding paragraph 10A.*a.*(5)) disassemble the crankcase front section and check for correctness of the assembly. Examine the propeller shaft oil seal sleeve journal and make certain that the sleeve fits correctly and that the oil seal rings are correctly gapped.

(7) If leakage is in excess of 3.5 pounds per minute and examination shows the rings are properly fitted, disassemble and install a new or reworked oil sleeve. If the use of another sleeve does not prevent excessive leakage and the propeller shaft oil seal sleeve journal is worn or out-of-round, it will be permissible to grind the shaft. The shaft may be ground to .010-inch maximum undersize in diameter. Remove only the minimum amount of material necessary to accomplish this rework. After grinding, the propeller shaft will be chrome plated and finished to standard dimensions shown in drawings.

11. STATIONARY REDUCTION GEAR—.5625 (16:9) REDUCTION GEAR.

a. Place the propeller shaft and pinion assembly on the assembly block. Install the stationary reduction gear in position on the propeller shaft, meshing the teeth on the gear with the pinion gear teeth. Place the pinion guard ring in position on the stationary reduction gear. Install two aligning studs (Tool No. 800695) in tapped holes in the stationary reduction gear. These studs will facilitate alignment of the stationary reduction gear and the crankcase front section upon assembly of these parts.

12. STATIONARY REDUCTION GEAR SUPPORT OR OIL SLEEVE SUPPORT—.5625 (16:9) REDUCTION GEAR OR DIRECT DRIVE.

a. Before assembling the stationary reduction gear support on the propeller shaft, check the thrust bearing side clearance in the same manner as previously described for .666 (3:2) reduction geared engines.

13. THRUST BEARING SPACER—.5625 (16:9) REDUCTION GEAR OR DIRECT DRIVE.

a. Fit new oil rings in the thrust bearing spacer, insuring that the proper ring side clearance and gap are obtained. Refer to the Table of Limits in Section XII.

b. Lubricate the thrust bearing spacer and ring assembly and the inside diameter of the stationary reduction gear support with engine oil. Install the spacer and ring assembly in the support, exercising care to insure that the rings are not damaged. The end of the spacer which is

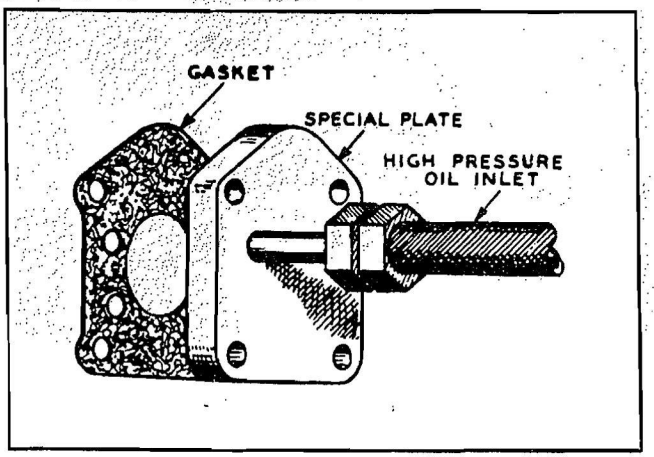

Figure 180B—Special Plate Governor Substituting Cover

provided with a lip on the inside diameter must be toward the front of the support.

c. Install the stationary reduction gear support and the thrust bearing spacer and ring assembly over the aligning studs in the stationary reduction gear. It may be necessary to tap the spacer into place on the propeller shaft, since the clearance between the spacer and the shaft is small. Take care that the position of the spacer relative to the support is not changed during the installation of these parts on the propeller shaft, since that might allow one of the rings to slip past the end of the support. Insure that the lip on the inside diameter of the spacer is bottomed on the shoulder on the propeller shaft, and that the stationary reduction gear support is bottomed on the gear.

14. THRUST BEARING—.5625 (16:9) REDUCTION GEAR OR DIRECT DRIVE.

a. Heat the thrust bearing, or the halves of the inner race if the bearing is of the split inner race type, in an oil bath maintained at a temperature of 121° C (250° F) for five minutes. Install the bearing on the propeller shaft, insuring that the puller lip on the inner race is toward the front end of the shaft. If the bearing incorporates a split inner race, first install the rear half of the inner race, then the outer race, retainer and balls, and finally the front half of the inner race. Tap the front end of the inner race after installation to insure that it is bottomed on the thrust bearing spacer.

b. Lubricate the thrust bearing retainer in the crankcase front section with corrosion preventive mixture. Install the front section over the aligning studs in the stationary reduction gear. Refer to Figure 181. It may be necessary to wait until the thrust bearing has cooled before installing the front section, since the outer race of the bearing may have expanded sufficiently during heating to prevent its entering the retainer. Insure that the lip on the front end of the thrust bearing retainer is bottomed on the bearing outer race.

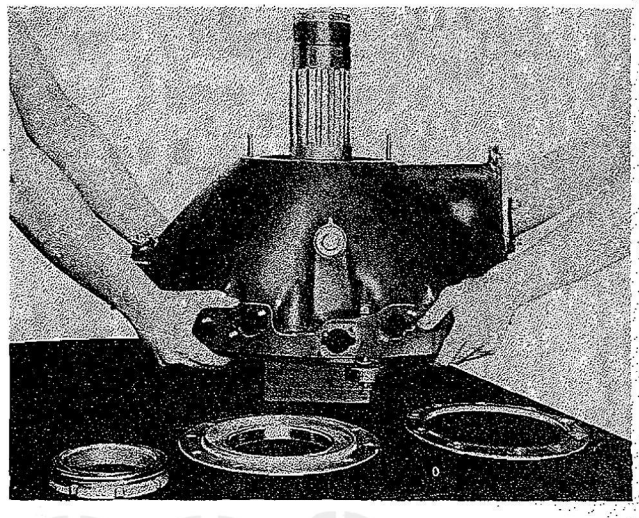

Figure 181—Installing Crankcase Front Section Over Propeller Shaft

c. Install flat washers and cap screws in the counterbored holes in the front section. Use a torque indicating wrench to tighten these cap screws, and observe the proper torque value. Refer to the Table of Limits in Section XII. Remove the two aligning studs from the stationary reduction gear.

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15. CRANKCASE FRONT SECTION FLANGE AND SPACER—.5625 (16:9) REDUCTION GEAR OR DIRECT DRIVE.

a. Install a new gasket, the front section flange, and aluminum spacer in position on the crankcase front section, and secure with ten flat washers and the special cap screws. Use a torque indicating wrench when tightening the cap screws. Refer to the Table of Limits in Section XII for the proper torque to be used. Lockwire the cap screws in pairs.

16. THRUST NUT—.5625 (16:9) REDUCTION GEAR OR DIRECT DRIVE.

a. Fit new rings, and install on the propeller shaft in the same manner as described for .666 (3:2) reduction geared engines in this section, paragraph 9.

17. THRUST BEARING, PROPELLER SHAFT AND TORQUE INDICATOR PARTS—.666 (3:2) AND .5625 (16:9) REDUCTION GEARED ENGINES HAVING A TORQUE INDICATOR.

a. In engines provided with a torque indicator, the torque arm and support assembly must be installed in the crankcase front section before the beveled booster pump drive gear.

b. Assemble the torque arm and support assembly by installing the balls which hold these parts together. To do this, stand the support on a bench, sleeve end down. Hold the torque arm in position over the support so that the circular slots in the torque arm and support are aligned. Insert the balls, one by one, in the circular hole formed by the mating slots. When all the balls are installed, turn the torque arm relative to the support so that the circular slots are misaligned.

c. Place the crankcase front section on a bench, front end down. Lubricate and install the thrust bearing front spacer and the thrust bearing in the retainer in the front section. Check the thrust bearing side clearance. Refer to the Table of Limits in Section XII.

d. Install the torque arm and support assembly in the front section over the projecting end of the thrust bearing. To do this, first insert the end of the torque arm through the hole provided for it in the top of the front section. Then press the support in position on the bearing. Be careful not to scratch or otherwise damage any parts when installing this assembly. Turn the support on the bearing until the attaching cap screw holes are aligned with the holes in the crankcase front section. Lift the front section and invert it, holding the torque arm support in position by hand, and place the assembly, front end up, on a block underneath the support. The block should be high enough to raise the front section parting flange clear of the bench. Install two flat washers and cap screws in the counterbored holes in the front section. Use a torque indicating wrench to tighten these cap screws, and observe the proper torque value. Refer to the Table of Limits in Section XII.

e. Install a new crankcase front section flange gasket, the flange, and the aluminum spacer in position on the front section, and secure with ten flat washers and the special cap screws. Use a torque indicating wrench to tighten the cap screws. Refer to the Table of Limits in Section XII for the proper torque value to be used.

f. Assemble the beveled booster pump drive gear and shaft and install in the crankcase front section in the same manner as previously described for the governor drive gear and shaft in engines without a torque indicator.

g. Place the front section on the bench, front end down, and install the thrust bearing spacer and ring assembly in the torque arm support in the same manner as previously described for .666 (3:2) reduction geared engines without a torque indicator. Install the stationary reduction gear in the splines of the torque arm support.

NOTE

The splines on the stationary reduction gear and the torque arm support are marked so that the gear may be reinstalled in its original position with relation to the support. Insure that the marked splines are lined up.

h. Install the propeller shaft and pinion assembly in the same manner as previously described in this section, paragraph 8, for .666 (3:2) reduction geared engines without a torque indicator, after heating the thrust bearing inner race and spacer, using the heating iron. Install the thrust nut, with new rings, also as in these engines.

i. Install the torque indicator housing and new gasket on the crankcase front section and secure with flat washers and castellated nuts. Lockwire the nuts. Install the valve with ring, in the torque indicator housing. Install the stop screw and lock nut loosely, by hand. To obtain the proper adjustment of the stop screw, be sure that the valve is seating properly in the recess in the torque arm and that the torque arm is contacting the stop screw. The proper adjustment of

the stop screw is obtained when the near edge of the valve ring is in line with the far edge of the metering slots in the valve housing sleeve, viewed from the open end of the housing. This position may be readily determined visually, using a light to assist in obtaining a fine adjustment. Tighten the stop screw until this adjustment is obtained, and then tighten the lock nut. Install the torque indicator housing cover and a new gasket, and secure with the bolts, nuts, and washers. Lockwire the nuts.

j. Install the booster pump drive gear and the governor drive gear in the booster pump housing. Install the booster pump housing cover and governor pump or substituting cover on the booster pump housing, using new gaskets between these parts. Secure these parts to the booster pump housing, using flat washers, plain nuts, and palnuts. Turn the booster pump drive gear by hand to check the ease of turning.

k. Install the booster pump housing on the crankcase front section, using new gaskets under the housing. Secure the housing to the front section and to the torque indicator housing with flat washers, castellated nuts, and cap screws. Turn the beveled booster pump drive gear inside the front section while tightening the attaching nuts and cap screws to insure proper alignment. Lockwire the nuts and cap screws. If the booster pump drive gear does not turn easily after tightening, the trouble may usually be traced to burrs on the pilot.

18. REDUCTON DRIVING GEAR.

a. Instructions for assembly of the reduction driving gear on the crankshaft are included in Section IX, paragraph 7.

19. VALVE TAPPETS AND VALVE TAPPET GUIDES.

a. Insure that all traces of finishing compound are removed from valve tappets and guides before assembly. Lubricate the valve tappet rollers, roller bushings, and pins with engine oil. Insert a roller bushing in its roller, and install these parts in the slotted end of the valve tappet. Install the roller pin. Lubricate the tappet and install it in its guide from the slotted end of the guide. Insure that each tappet is assembled with its respective tappet guide. Place a new tappet locking circlet on installing tool (Tool No. 83643). Refer to Figure 182. Stand the tappet and guide assembly on a bench, roller end down, place the installing tool with circlet in position in the guide, and push the circlet into the groove in the upper end of the tappet. Refer to Figure 183. Insure that the circlet is tight after installation.

b. Instructions for installation of the valve tappet and guide assemblies in the crankcase front section are included in Section IX, paragraph 10.

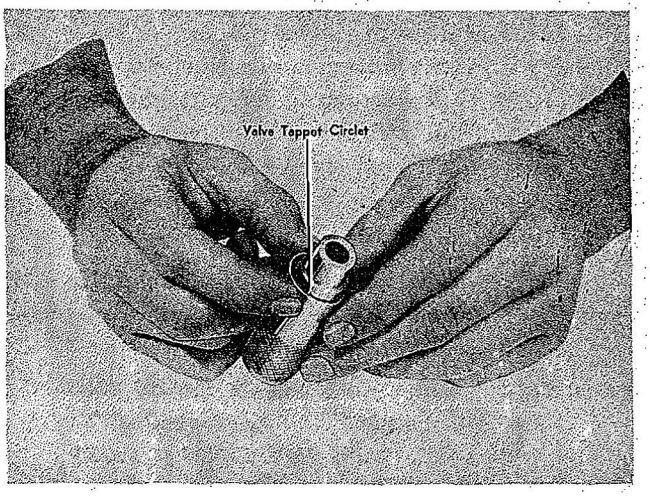

Figure 182—Valve Tappet Retaining Circlet on Installing Tool

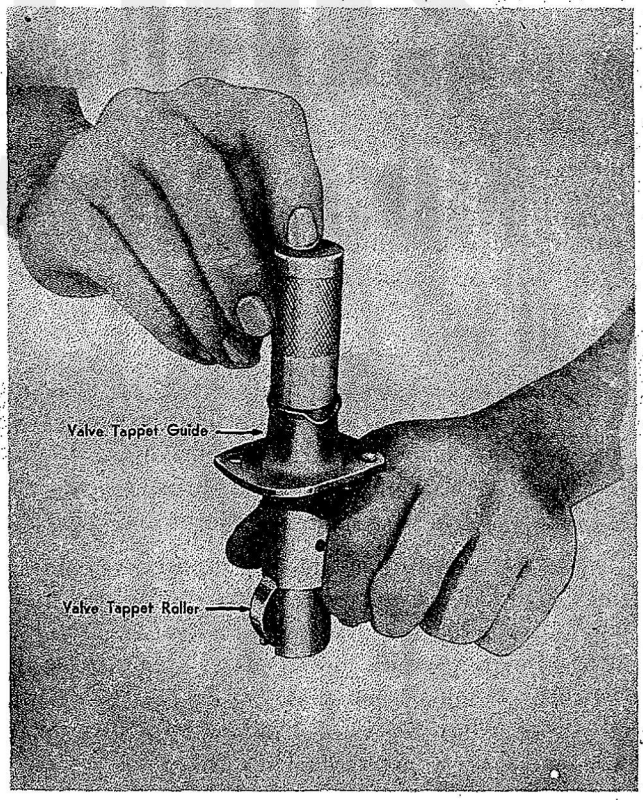

Figure 183—Installing Valve Tappet Retaining Circlet

20. CRANKCASE FRONT MAIN SECTION.

a. Before assembly of the crankcase front main section, refer to paragraph 1 of this section.

21. CAM AND CAM DRIVE.

a. Install the cam bearing ring spacer in position over the locating dowel pin in the crankcase main section front half, engaging the spacer splines with the cam bearing ring splines.

b. Install the cam on the bearing ring after lubricating these parts thoroughly.

c. Assemble the intermediate governor drive gear to the cam drive gear, using six attaching screws. Align the marked teeth on the two gears. Secure the screws with lock wire.

d. Install the oil passage plug in the cam drive gear bracket. Install the cam drive gear spacer over the front end of the cam drive gear supporting boss on the bracket. Lubricate the cam drive gear shaft and bushing, and insert the shaft in the bushing. Install the cam drive gear pinion on the splined end of the shaft, engaging the two marked splines on the pinion with the single marked spline on the shaft. Install the cam drive gear and pinion bolt in the cam drive gear shaft from the splined end of the shaft. Tighten the nut on the bolt, using a screwdriver in the slot in the bolt head to hold the bolt, and using a torque indicating wrench on the nut. Observe the proper torque value. Refer to the Table of Limits in Section XII. Cotterpin the nut.

e. Rotate the cam so that the two marked internal teeth are in line with the vertical centerline of the crankcase front section. Install the cam drive gear bracket spacer and the cam drive gear bracket over the splined cam bearing ring spacer on the cam supporting boss on the main section. Locate these parts correctly over the dowel pin in the main section. Time the cam and cam drive pinion by engaging the two marked teeth on the cam and the single marked tooth on the pinion. Refer to Figure 184.

f. Secure the cam drive gear bracket to the crankcase front main section by installing the eight retaining screws. Tighten these screws to the proper torque value, using a torque indicating wrench. Refer to the Table of Limits. Lockwire the screws in pairs.

22. CRANKCASE REAR MAIN SECTION.

a. Refer to paragraph 1 of this section before assembly of the crankcase rear main section.

23. SUPERCHARGER FRONT HOUSING.

a. If the impeller shaft front oil seal support has been removed, install it on the housing by first placing the gasket on the front face of the supercharger front housing. Place the support on the gasket and the ring on the support. Line up the holes and insert the eight screws from the inside of the supercharger front housing. Lock the screws to the ring by staking them at the threaded end with a center punch. Avoid staking the screws at the beginning of the thread.

b. Assemble the crankcase breather unit by installing the gasket, screen, gasket, and breather on the two attaching studs located on the top of the supercharger front housing. Secure the assembly with nuts and palnuts.

24. SUPERCHARGER REAR HOUSING.

a. Before assembly of the supercharger rear housing refer to paragraph 1 of this section.

b. Install all oil passage plugs in the supercharger rear housing.

c. Install the umbrella type oil seal vent in the supercharger rear housing. Cover the opening to the induction passage in the rear housing with a suitable plate drilled to pass over the carburetor adapter studs.

25. IMPELLER AND IMPELLER SHAFT.

a. Install the bronze washer over the impeller shaft splines so that the chamfered side of the washer is against the gear. Install the impeller shaft rear oil sleeve, with rings, on the shaft so that the oil seal rings are nearest the gear. Place the impeller shaft in position in the supercharger rear housing, taking care that the oil seal rings are not damaged. Place the impeller shaft thrust ring washer, if not already installed, and the spherical thrust ring on the rear end of the shaft, and install the laminated steel shim and the impeller shaft retainer on the supercharger rear housing. Secure retainer temporarily with the 5 flat head screws, tighten screws but do not stake at this time.

b. Check the impeller shaft end movement by inserting a feeler gage between the spherical thrust ring and the rear end of the impeller shaft, making certain that the spherical washer is not cocked. Refer to the Table of Limits in Section XII. If the impeller shaft end movement is not within the specified limits, add or subtract shims from the laminated shim used under the impeller shaft retainer and repeat this check. Do not stake the impeller shaft retainer attaching screws

at this time, since the retainer must be removed later to permit installation of the impeller drive gear.

c. Press the impeller on the impeller shaft as far as possible by hand. Complete the installation of the impeller using installing tool (Tool No. 800304) and adapter (Tool No. 800307). Tighten the four screws passing through the body of the installing tool into the tapped holes in the impeller. Install the adapter on the end of the rod which passes through the impeller shaft so that the pilot on the adapter is centered in the spherical thrust ring, and lock using the locking pin. The adapter tool should be seating on the impeller shaft retainer, and the locking pin should be seating in the semi-circular groove in the adapter.

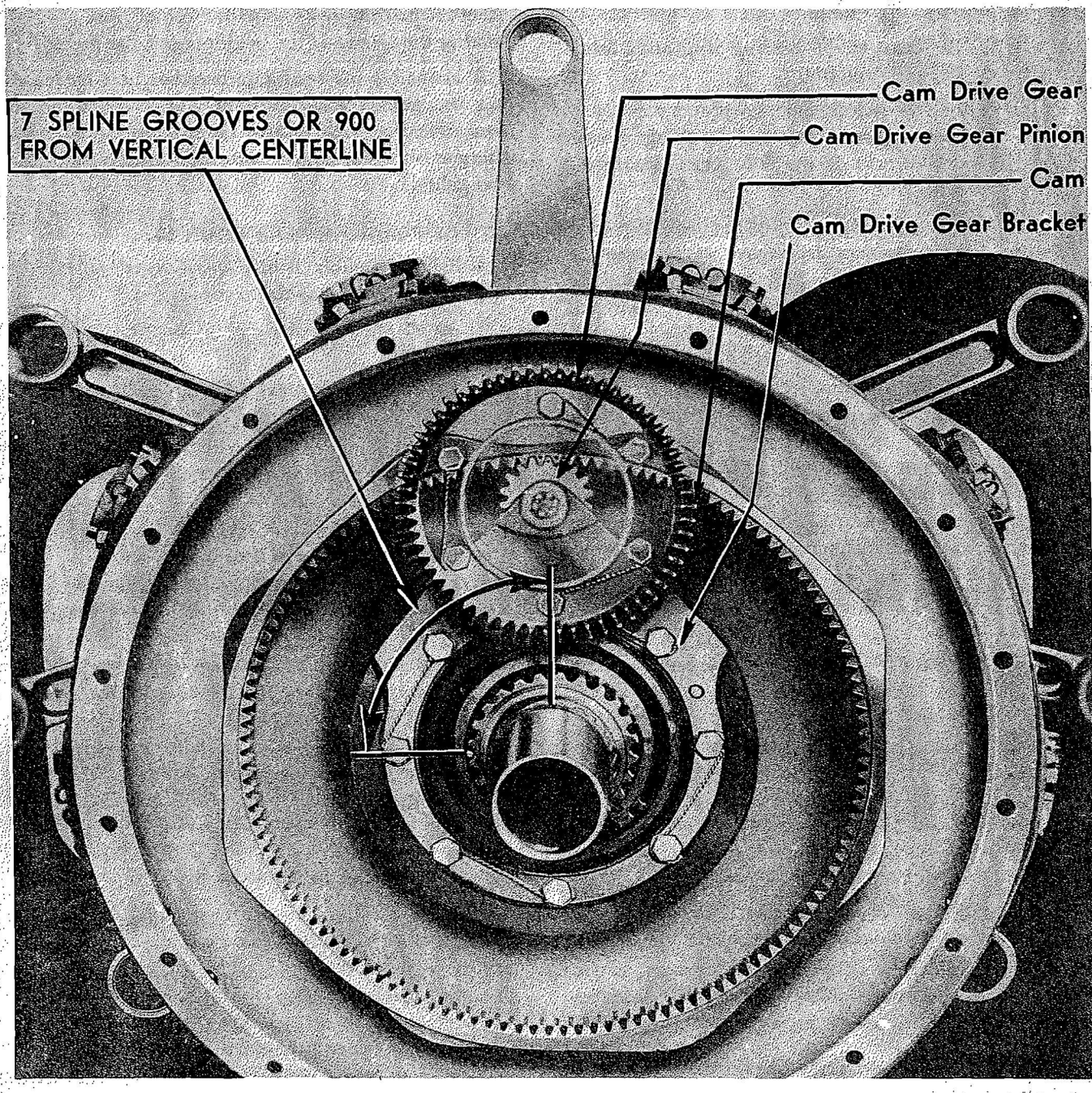

Figure 184—Timing Cam and Cam Drive Pinion, Showing also Proper Location of Reduction Driving Gear Blind Spline

Press the impeller on the shaft by turning the screw until the impeller hub is bottomed on the rear impeller shaft oil sleeve. Remove the installing tools. Place front oil seal spacer on the shaft then screw impeller retaining nut on shaft and tighten to insure that impeller is tight against the rear oil sleeve spacer.

d. Measure the clearance between the impeller blades and the diffuser plate, when the impeller is in the extreme rear position. Obtain this measurement using a feeler gage, checking at several points around the impeller circumference. Refer to Figure 185. Determine if this clearance is within the proper limits. Refer to the Table of Limits in Section XII. If the clearance is too large, remove the impeller, impeller shaft retainer, and the impeller shaft, and grind the required amount from the bronze washer which is installed forward of the impeller shaft gear. If the clearance is too small, remove the impeller, impeller shaft retainer, and impeller shaft, and install a thicker bronze washer, grinding in the same manner as above if necessary to obtain the proper clearance.

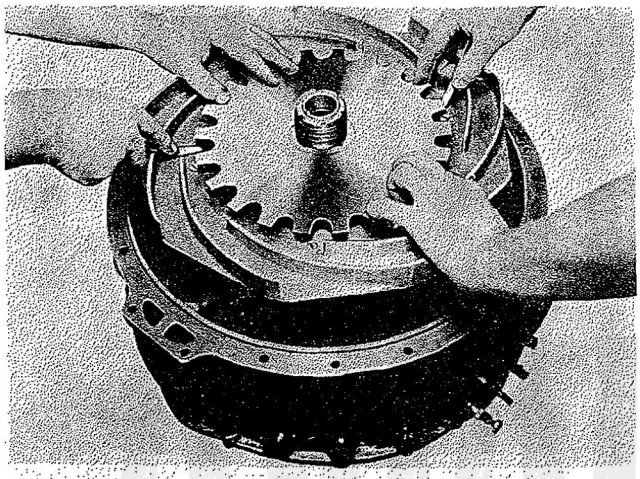

Figure 185—Checking Supercharger Impeller Clearance

e. After obtaining the proper impeller clearance, remove the impeller retaining nut and install the impeller nut lock then reinstall the nut. Lock the impeller using the impeller holder (Tool No. 802395) and adapter (Tool No. 84534). Tighten the impeller nut using lug wrench (Tool No. 82267). If high torque wrench (Tool No. 802700) impeller holding tool (Tool No. 803469) and impeller nut adapter (Tool No. 84534) are available, they should be used so that the impeller nut can be tightened to its proper torque value of 3750 and 4250 inch-pounds. Bend one tab of the impeller nut lock into a slot in the nut. Remove the tools from the supercharger rear housing.

26. SUPERCHARGER REAR HOUSING COVER.

a. Before assembly of the supercharger rear housing cover refer to paragraph 1 of this section.

b. Install all oil passage plugs in the supercharger rear housing cover.

27. ACCESSORY DRIVE AND STARTER SHAFT.

a. Chill the oil retainer plug by immersing it in a solution of dry ice and alcohol for five minutes. Install the plug in the internally splined hub of the shaft, with the long spring pilot diameter of the plug toward the anti-propeller end of the shaft. Ensure that the plug is of the correct type, which may be identified by the .50 in. spring pilot diameter. Do not force or tap the plug in any way. Install a new retainer plug snap ring into the groove in the shaft splines, and ensure that the ring is correctly seated. When a replacement retainer plug is to be installed ensure that the resulting fit of the plug in the shaft will be within the limits as stated in Section XII.

b. Place the accessory drive gear on the accessory drive and starter shaft, and turn the gear to engage the internal lugs on the gear with the mating ears on the shaft. Install these parts, gear end up, in holding fixture (Tool No. 800360-1) held in a vise. Install locating plug (Tool No. 800360-7) between two of the ears on the shaft. Place a spring and pin assembly in the clamping plate (Tool No. 800360-11) and compress the spring by tightening the clamp. Place the clamping plate over the end of the shaft, allowing the knurled handle of the locating plug to extend into the hole in the plate. Install the bushing (Tool No. 800360-6) in the clamping plate, over the end of the shaft, centralizing the shaft in the plate. Using the installing tool (Tool No. 800360-13), rap the springs and pins into place. Refer to Figure 186. Repeat this operation to install the remaining springs and pins, after removing the locating plug.

c. Attach the accessory drive gear rear plate to the shaft, using the five screws. Lockwire the screws in groups of three and two.

28. SINGLE-SPEED IMPELLER DRIVE.

a. In engines equipped with a single-speed impeller drive, proceed with the assembly of the supercharger rear housing and cover as follows: Assemble the magneto drive gears and the dual accessory drive gear to their respective shafts by installing the attaching screws. Insure that the proper cap screws are used. The proper screws for use in these locations are 3/8 in. long, measured from the underside of the screw head to the end of the thread. Lockwire the screws in pairs.

b. Place the supercharger rear housing, rear end up, on an assembly and disassembly stand, also used in the disassembly of the supercharger rear housing and cover. Before installing the impeller drive gear and pinion in position in the bushing in the rear housing, it is necessary

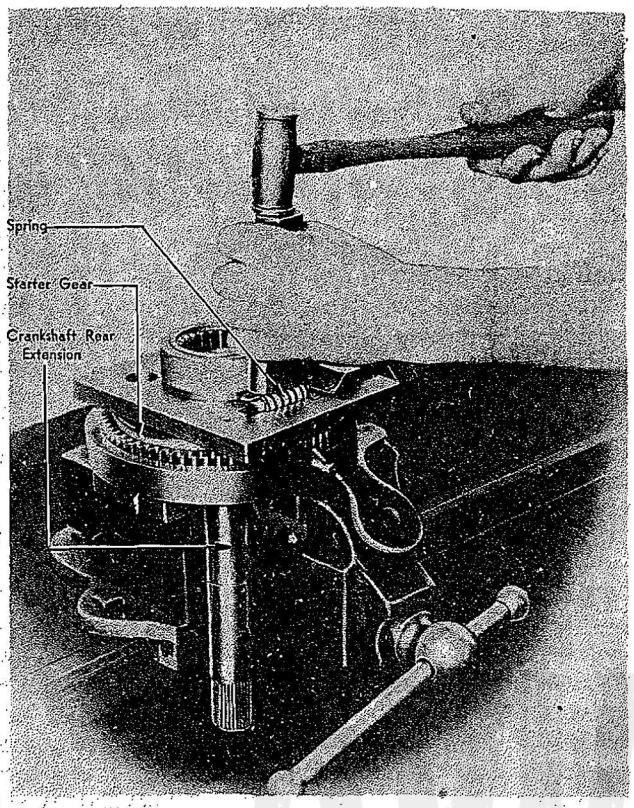

Figure 186—Assembling Accessory Drive and Starter Shafts

to remove the impeller shaft retainer, which was previously assembled to the rear housing in order to check the impeller shaft movement. Remove the impeller shaft retainer attaching screws and the retainer, install the impeller drive gear and pinion in its bushing in the rear housing, and reinstall the retainer and attaching screws. Stake the attaching screws into the retainer after tightening, to prevent loosening of the screws. Fit a new oil seal ring in the groove in the impeller shaft retainer, insuring that the proper ring side clearance and gap are obtained. Install the bronze accessory drive and starter shaft thrust ring in the recess in the impeller shaft retainer.

c. Install the accessory drive and starter shaft in position in the impeller shaft, meshing the accessory drive gear with the impeller drive pinion. Take care to insure that the splines on the front end of the accessory drive and starter shaft do not scratch or score the impeller shaft bushings, and that the impeller shaft retainer oil seal ring is not damaged.

d. Check the end movement of the accessory drive and starter shaft at this time. To do this, install the supercharger rear housing cover and gasket temporarily, and secure with three attaching nuts on each side. Locate a dial indicator on the rear cover so that the indicator spindle contacts the end of the accessory drive and starter shaft. Move the shaft up and down by hand, holding the end of the shaft which extends through the impeller shaft.

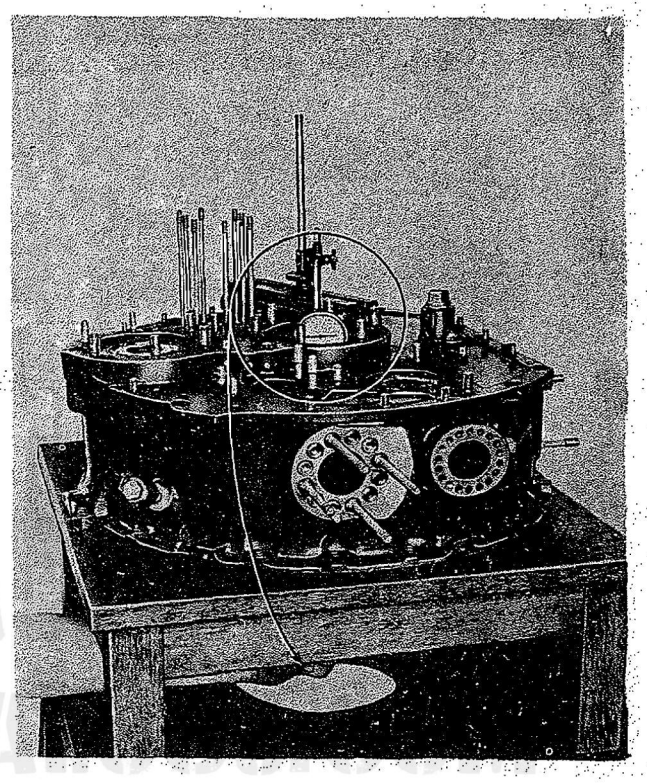

Figure 187—Checking Accessory Drive and Starter Shaft End Clearance

Refer to figure 187. Note the difference in the indicator readings, which is the end movement of the shaft. Refer to the Table of Limits in Section XII. If the end movement is too small, grind the required amount from the bronze accessory drive and starter shaft thrust ring. If the end movement is too great, install a new thrust ring. When the proper end movement is obtained, remove the supercharger rear housing cover.

e. Place the oil pump drive gear and the dual accessory drive gear in position in the supercharger rear housing, meshing these gears with the accessory drive gear. Place the magneto drive gears in position, meshing these gears with the oil pump drive gear and the dual accessory drive gear. Place the generator drive gear in position, meshing this gear with the impeller drive pinion.

f. Insure that the parting surfaces of the super-

charger rear housing and cover are clean and smooth. Install new gaskets on the supercharger rear housing rear parting surface and on the rear housing oil suction flange. Hold the supercharger rear housing cover in position over the rear housing. Place a fiber drift through the generator drive gear bushing in the rear cover, and enter the end of the drift into the rear end of the generator drive gear shaft. Use of the drift will assist in entering the generator drive gear shaft in its bushing in the rear cover when the rear cover is lowered. Lower the rear cover onto the supercharger rear housing, taking care to insure that the ends of all shafts in the rear housing enter their respective bushings in the rear cover. Refer to Figure 188.

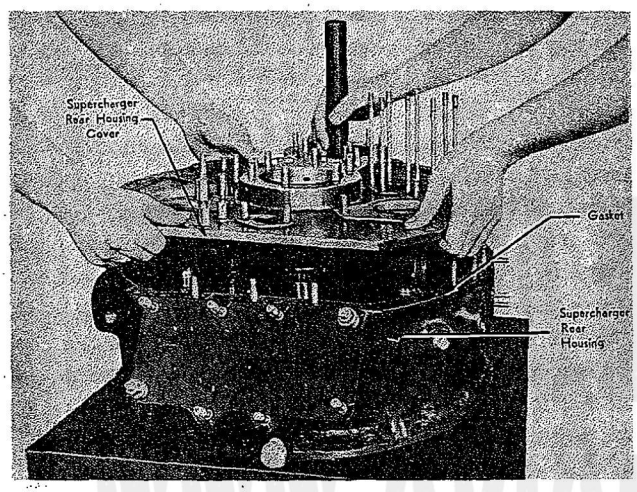

Figure 188—Installing Supercharger Rear Housing Cover

g. To secure the supercharger rear housing cover to the rear housing, install flat washers and plain hexagonal nuts on all rear cover attaching studs except those which also serve for attachment of the magnetos, oil pump, and dual accessory drive housing. Use a torque indicator wrench when tightening these nuts and observe the proper torque value. Refer to the Table of Limits in Section XII. Lock the nuts with palnuts. Install flat head machine screws in all countersunk holes in the rim of the rear cover except those in the dual accessory drive housing mounting pad, and install flat washers, plain nuts and palnuts on the screws. Install the three slotted round nuts under the generator mounting pad using wrench (Tool No. 83381). Install the three puller hole plugs and gaskets in the tapped holes in the rim of the rear cover.

h. Install the two-speed clutch oil control valve substituting cover and gasket on the rear cover, and secure with three flat washers, plain hexagonal nuts, and palnuts.

29. TWO-SPEED IMPELLER DRIVE (PLATE CLUTCH TYPE).

a. In engines equipped with a two-speed impeller drive of the plate clutch type, proceed with assembly of the supercharger rear housing and cover as follows, after assembly of the accessory drive and starter shaft.

b. Assemble the low-speed clutch in accordance with the following instructions: Place the low-speed clutch sleeve in position over the attaching studs on the front side of the supercharger rear housing cover. Fit a new piston ring in the low-speed clutch piston, insuring that the proper ring side clearance and gap are obtained. Refer to the Table of Limits in Section XII. Install the piston and ring assembly in the low-speed clutch sleeve, fitting the inside diameter of the piston on the protruding end of the intermediate impeller drive shaft rear bushing, and meshing the serrations in the outside diameter of the piston with the internal serrations in the sleeve.

c. Installing tool (Tool No. 84692) is used to assist in the assembly of the low-speed clutch release spring. Loosely screw the tapered end of the bolt provided with this tool into the fiber body of the tool. Insert the body of the tool into the bronze intermediate impeller shaft rear bushing in the rear cover. Tighten the bolt in the split fiber body sufficiently to hold the body in the bushing against the pressure of the spring, when installed. Refer to Figure 189.

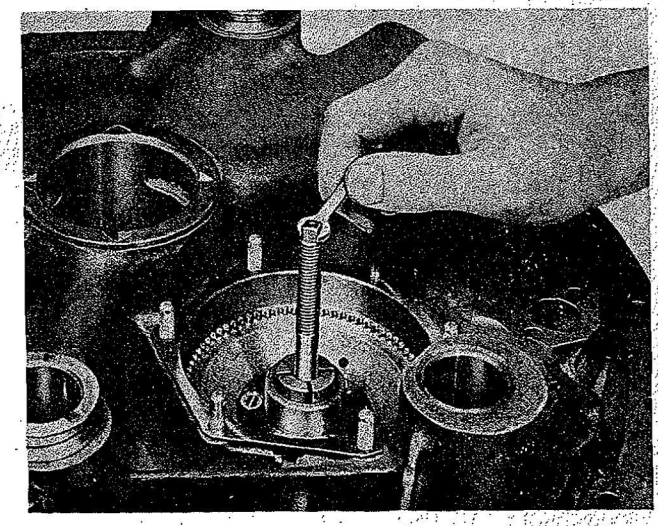

Figure 189—Assembling Low Ratio Clutch (Tool in Position)

d. Place the low-speed clutch release spring over the installing tool and into the annulus in the hub of the piston. Place the conical bronze spacer on the spring, with the small diameter of the spacer extending inside the spring. Install the thrust washer on the spacer with the lugs down. Install the sun gear on the thrust washer, large end down. Push the sun gear down, compressing the spring, and at the same time mesh the six lugs on the thrust washer with the slots in the piston lock. Hold the parts in this position and screw the knurled nut (Tool No. 84692-3) on the assembly bolt. Refer to Figure 190.

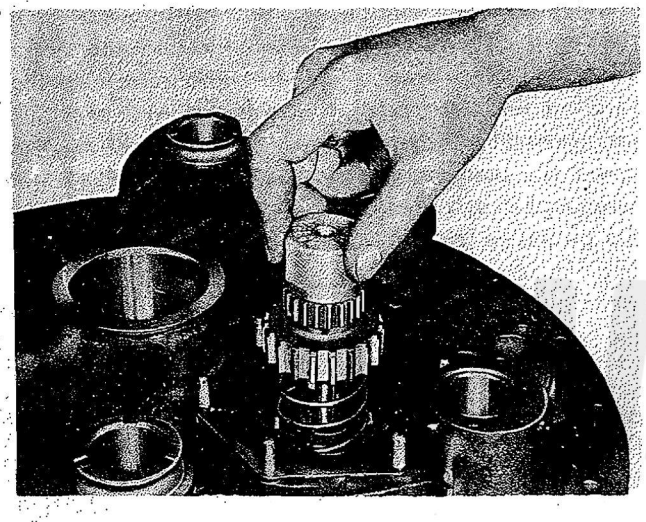

Figure 190—Attaching Nut to Assembly Tool

e. Lubricate the low-speed clutch disks and plates with corrosion preventive mixture, and install one disk over the splines of the sun gear so that the splined extension of the disk is nearest the piston. Next install one flat steel plate, either side down. Install in succession another disk, another plate, and the last disk in the same manner. Align the lugs on the outside diameter of the plates so that they will mesh with the slots in the rim of the low-speed clutch housing, when installed. Install the housing, and secure to the attaching studs in the rear cover by six flat washers and castellated nuts. Use a torque indicating wrench when tightening the nuts, and observe the proper torque value. Refer to the Table of Limits in Section XII. Do not cotterpin the nuts at this time, since it may be necessary to disassemble the low-speed clutch in order to adjust the intermediate impeller drive shaft end movement. Remove the installing tool.

f. Assemble the high-speed clutch in accordance with the following instructions: Place the high-speed clutch gear in the holding fixture (Tool No. 84668) and clamp the fixture in a vise. Ensure that the edges of the gear rim at the four lockwire notches incorporate .030 in. radii at both the inner and outer diameters. Fit a new piston ring in the high-speed clutch piston, insuring that the proper ring side clearance and gap are obtained. Refer to the Table of Limits in Section XII. If it is found necessary to increase the gap of this ring, remove the required amount of metal from the end of the ring opposite the rectangular notch. Install the piston and ring assembly in the gear, insuring that the six driving lugs on the piston are inserted in the slots in the gear. Place the splined adapter on the piston with the shouldered end down.

g. Lubricate the high-speed clutch disks, plates, and retainer with corrosion preventive mixture, and install one bronze disk over the splines of the adapter with the tapered hub facing away from the piston. Next install one steel plate, with the recessed side facing away from the piston and with the flats in the splines aligned with the slots in the gear. Install in succession another disk, another plate, and the last disk in the same manner. Finally, install the retainer, with the tapered recess facing away from the piston and with the flats in the splines aligned with the slots in the gear. Insert the end of a length of spring steel wire in the annulus formed by the grooves in the high-speed clutch gear and retainer. Use the special spring steel lockwire having a diameter of .090 to .092 in. Start the wire into the annulus at the widest slot in the gear, and push it through the annulus until it emerges in the same slot. Refer to Figure 191. Bend the ends of the wire outward from the notch to a 30 deg to 40 deg angle in order to prevent the wire from sliding in the housing. Do not bend the wire sharply

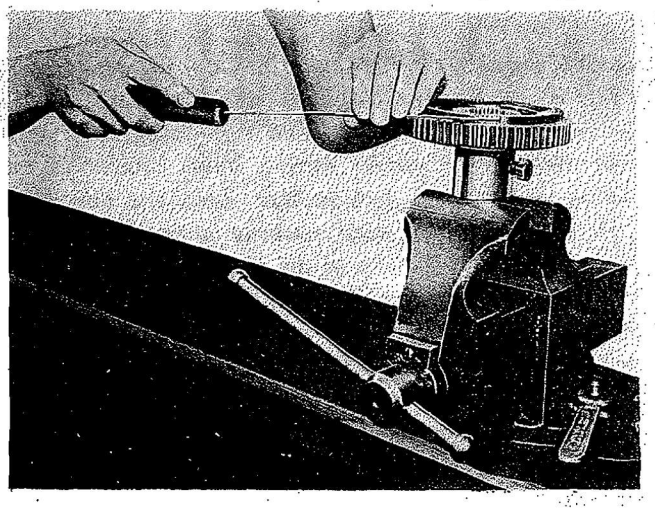

Figure 191—Installing Spring Steel Wire (High Ratio Clutch)

around the edges. Cut the wire so that it is flush with or slightly below the contour of the shoulder on the gear. Remove the gear from the fixture.

h. Install the check valve and spring in the front end of the intermediate impeller drive shaft. Install and tighten the pipe plug in the threads in the shaft, over the check valve spring. Check the valve for leakage under pressure in the following manner: Hold the front end of the intermediate impeller drive shaft in gasoline, and apply an air pressure of 6 lb per sq in. at the rear end of the shaft. If leakage is noted, evidenced by bubbling of the gasoline, it will be necessary to lap the valve into its seat.

i. Place the intermediate impeller drive shaft in holding fixture (Tool No. 800763). Install the sun gear floating bronze bushing over the rear end of the intermediate impeller drive shaft, so that the flanged end of the bushing contacts the pinion carrier. Install the pinion bushings and pinions on the carrier trunnions on the shaft, with the chamfered end of the bushings and the shouldered end of the pinions at the base of the trunnions. Install the pinion lock in the lock installing tool (Tool No. 802925). Place the tool and lock in position on the trunnion and tighten the wing nut until the lock is seated in the trunnion groove.

CAUTION

Do not install the locks with the open end toward the shaft, as they will then come out of their grooves during operation, due to centrifugal force. Make certain that only the later type pinion locks, which are dyed purple on one side for identification, are installed. After installation, check to see if a tight fit has been obtained. Reject the lock if it is loose. Do not attempt to change its shape. Locks which have been installed and removed, must never be reinstalled.

j. Remove the intermediate impeller drive shaft assembly from the holding fixture.

k. The high-speed clutch gear and intermediate impeller drive shaft have been factory mated to obtain minimum runout and are suitably marked to permit reassembly in their original positions. One of these marks is located on one of the high-speed clutch gear teeth at the center of one of the slots in the gear and the other mark is located on the top of one of the intermediate impeller drive shaft pinion trunnions.

l. If either the high-speed clutch gear or the intermediate impeller drive shaft has been removed or the mating marks are not visible, install the splined end of the assembled intermediate impeller drive shaft into the high-speed clutch assembly, and mount these parts on V-blocks. Clamp the rear end of the shaft lightly on the sun gear floating bushing to allow the shaft to turn. Place an adjustable V-block between the pinion supporting flange and high-speed clutch, and level the assembly. Measure the amount of runout of the high-speed clutch gear journal, using a dial indicator placed near the front face of the gear. Refer to Figure 193. Note this reading. Remove the high-speed clutch gear from the intermediate impeller drive shaft, install it in the next spline location and again measure the runout. Repeat this procedure until the point of minimum runout is obtained, and mark by acid etching one tooth of the high-speed clutch gear at the center of one of the slots in the gear. Place the mating acid etch mark across the top of the pinion trunnion directly in line with the marked tooth.

m. Remove the assembly from the V-blocks. Remove the intermediate impeller drive shaft from the high-speed clutch gear.

n. Place the supercharger rear housing, rear end up, on an assembly and disassembly stand, also used in the disassembly of the supercharger rear housing and cover. Before installing the high-speed clutch gear in position in the bushing in the rear housing, it is necessary to remove the impeller shaft retainer, which was previously assembled to the rear housing in order to check the impeller shaft end movement. Remove the im-

Figure 192 deleted in revision dated 5 October 1945.

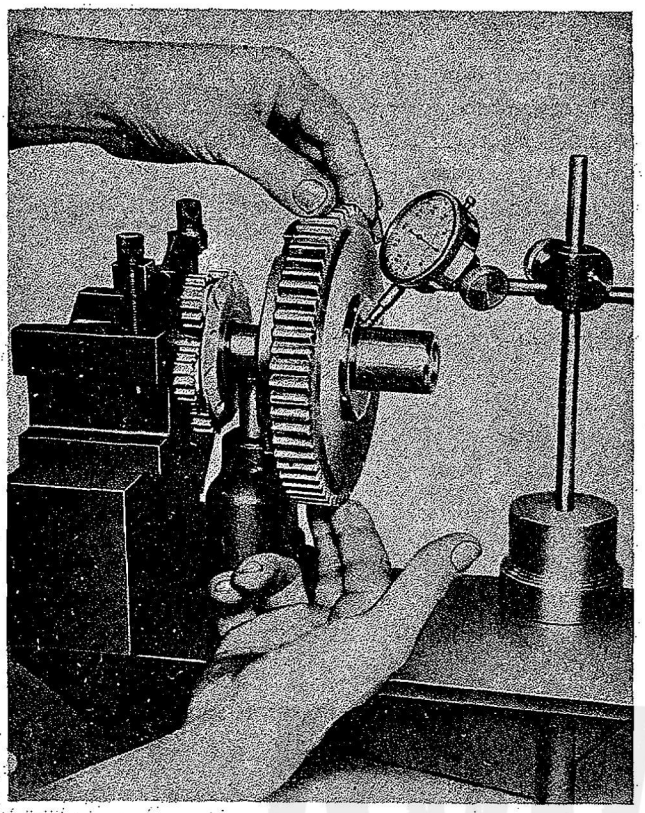

Figure 193—Checking High Ratio Clutch Gear Alignment

peller shaft retainer attaching screws and the retainer, install the high-speed clutch gear in its bushing in the rear cover, and reinstall the retainer and attaching screws. Stake the attaching screws into the retainer after tightening. Fit a new oil seal ring in the groove in the impeller shaft retainer. Install the bronze accessory drive and starter shaft thrust ring in the recess in the retainer in the same manner as described in this section, paragraph 28, for engines having a single-speed impeller drive.

o. Install the accessory drive and starter shaft in position in the impeller shaft. Take care to insure that the splines on the front end of the accessory drive and starter shaft do not scratch or score the impeller shaft bushings, and that the impeller shaft retainer oil seal ring is not damaged.

p. Measure the clearance between the front face of the accessory drive gear and the rear face of the high-speed clutch gear, using a feeler gage, with both gears in the extreme forward position. Refer to Figure 194. Record this measurement for later use in determining the minimum clearance which could exist between

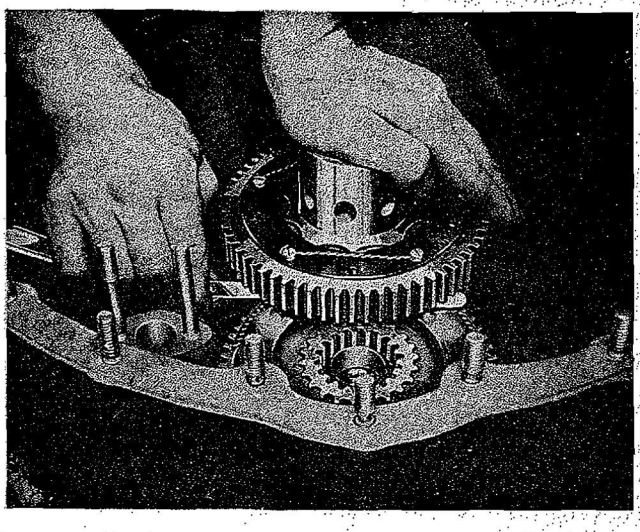

Figure 194—Checking Accessory Drive and High Ratio Clutch Gear Clearance

these gears. The limits specified in the Table of Limits refer to the minimum clearance, with the accessory drive gear in its extreme forward position and the intermediate impeller drive gear in its extreme rear position.

q. Place the high-speed release spring in position in the splined adapter. Install the bell-shaped intermediate impeller drive gear on the intermediate impeller drive shaft, meshing this gear with the five pinions. Install the intermediate impeller drive gear and shaft together in the high-speed clutch gear. Engage the splines on the end of the shaft with the internal splines in the gear, and mesh the intermediate impeller drive gear external teeth with the accessory drive gear teeth and with the internal teeth in the high-speed clutch adapter. Insure that the marked trunnion on the intermediate impeller drive shaft is aligned with the marked tooth on the high-speed clutch gear. Screw the checking rod (Tool No. 84761) into the tapped hole in the end of the intermediate impeller drive shaft.

r. Check the end movement of the accessory drive and starter shaft and the end movement of the intermediate impeller drive shaft at this time, before installing the accessory driving gears in the rear housing. To do this, install the supercharger rear housing cover and gasket temporarily, and secure with three attaching nuts and washers in each side. Allow the checking rod to extend through the tapped hole in the rear cover directly behind the intermediate impeller drive shaft rear bushing. Check the end movement of the

accessory drive and starter shaft in the same manner as described in this section, paragraph 28, for engines having a single-speed impeller drive. Adjust the end movement if it is not within the specified limits.

s. Check the end movement of the intermediate impeller drive shaft in the following manner: Install the collar on the checking rod, and lock by tightening the lock screw. Screw the knurled handle on the end of the rod. Install a dial indicator on a surface gage, and adjust the position of the indicator so that the indicator spindle contacts the upper side of the collar on the checking rod. Move the intermediate impeller drive shaft up and down as far as possible by moving the checking rod, holding the knurled handle. Refer to Figure 195. Note the difference in the indicator readings, which is the end movement of the shaft. Insure that this end movement is greater than the minimum permissible. Refer to the Table of Limits in Section XII.

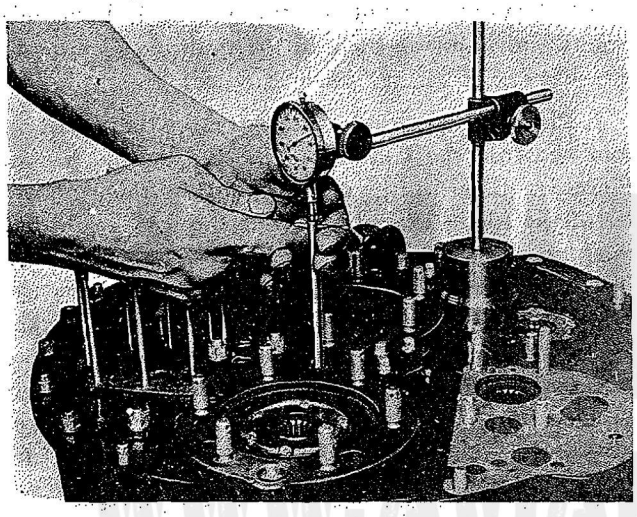

Figure 195—Checking Intermediate Impeller Drive Shaft End Clearance

t. Determine the minimum clearance which could exist between the accessory drive gear and the high-speed clutch gear. The minimum clearance is obtained when the accessory drive gear is in its extreme forward position and the intermediate impeller drive gear is in its extreme rear position. To determine this clearance subtract the end movement of the intermediate impeller drive shaft from the clearance between the accessory drive gear and the high-speed clutch gear, previously measured, when both gears were in the extreme forward position. Insure that the resulting figure is greater than the minimum permissible. Refer to the Table of Limits in Section XII.

u. If the end movement of the intermediate impeller drive shaft is too small, remove the rear cover and the low-speed clutch housing and grind the required amount from the conical bronze spacer located at the front end of the low-speed clutch release spring. If the minimum clearance between the accessory drive gear and the high-speed clutch gear is too small, remove the rear cover and the low-speed clutch housing and install a thicker spacer, grinding in the same manner as above if necessary to obtain the proper clearance. In either case, check again the end movement of the intermediate impeller drive shaft and determine again the minimum clearance between the accessory drive gear and the high-speed clutch gear before proceeding with the assembly. When the proper clearances have been obtained, remove the supercharger rear housing cover and remove the checking rod. Remove the intermediate impeller drive gear and shaft in order to permit installation of the generator drive gear.

v. Secure the nuts attaching the low-speed clutch housing to the supercharger rear housing cover by installing cotter pins in the nuts. Assemble the magneto drive gears and the dual accessory drive gear to their respective shafts in the same manner as described in this section, paragraph 28, for engines having a single-speed impeller drive.

w. Place the oil pump drive gear and dual accessory drive gear in position in the supercharger rear housing, meshing these gears with the accessory drive gear. Place the magneto drive gears in position, meshing these gears with the oil pump drive gear and the dual accessory drive gear. Place the generator drive gear in position in the rear housing. With the splined high-speed clutch adapter in position in the high-speed clutch assembly, and with the high-speed clutch release spring in the adapter, install the intermediate impeller drive gear and shaft together. Engage the splines on the end of the shaft with the internal splines in the high-speed clutch gear, and mesh the intermediate impeller drive gear with the accessory drive gear, the generator drive gear, and the high-speed clutch adapter. Refer to Figure 196. Insure that the marked trunnion on the intermediate impeller drive shaft and the marked tooth on the high-speed clutch gear are aligned.

x. Install the supercharger rear housing cover on the rear housing and attach the rear cover to the rear housing in the same manner described in this section,

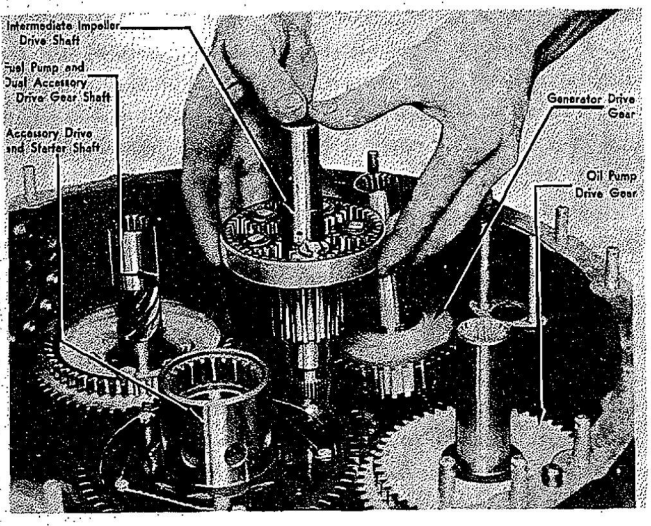

Figure 196—Installing Intermediate Impeller Drive Shaft and Pinion Gear Assemblies

paragraph 28, for engines having a single-speed impeller drive.

y. Lubricate and install the two-speed clutch control valve bronze sleeve in its recess in the rear cover, with the end in which a flat is machined facing towards the rear. Place the valve spring, valve spring washer, and inner and outer valve stem packing rings on the valve stem. Lubricate and install the valve assembly in the control valve housing. Push the valve in against the spring tension and install a spacer and nut on the threaded end of the valve stem. Tighten the nut against the spring tension until the valve is in the high-speed ratio, or retracted, position.

z. Place a new gasket on the supercharger rear cover, install the control valve assembly, and secure with plain washers and elastic stop nuts. Remove the nut and spacer from the valve stem. Check the operation of the valve for full travel and freedom from binding.

30. TWO-SPEED IMPELLER DRIVE (ROLLER CLUTCH TYPE).

a. On engines equipped with a two-speed impeller drive of the roller clutch type, proceed with the repair and assembly of the supercharger rear housing and cover as follows after the assembly of the accessory drive and starter shaft:

b. Install the high speed clutch sleeve in its recess in the rear cover. It may be necessary to tap the sleeve into place with a fiber mallet. When the flange of the sleeve seats against the rear cover, check the gap of the piston ring in the sleeve. Make sure that the ring is not seating in the radius at the bottom of the sleeve. To insure this, it is good practice to first insert an old ring with a large gap in the sleeve and then the new piston ring, thus allowing the ring to seat square in the sleeve. After making this check, be sure to remove both rings. Install the new ring in the piston and check the side clearance. When the gap and the side clearance have been checked, and corrected if necessary, install the piston and ring assembly in the sleeve meshing the serrations on the outside diameter of the piston with those in the sleeve.

c. Installing tool (Tool No. 84692) is used to assist in the assembly of the high speed clutch release spring. Loosely screw the tapered end of the bolt provided with this tool into the fiber body of the tool. Insert the fiber body into the bronze bushing in the rear cover. Tighten the bolt in the split fiber body sufficiently to hold the body in the bushing against the pressure of the spring, when installed.

d. Place the clutch release spring over the installing tool and into the annulus in the hub of the piston. Place the spacer on the spring, with the small diameter of the spacer extending inside the spring. Install the high speed clutch thrust washer on the spacer with the lugs down. Install the clutch adapter on the thrust washer, shouldered end down. Push the adapter down, compressing the spring, and at the same time mesh the six lugs on the thrust washer with the slots in the piston lock. Hold the parts in this position and screw the knurled nut (Tool No. 84692-3) on the assembly bolt.

e. Lubricate the high speed clutch disks and plates with corrosion preventive mixture and install one disk over the splines of the adapter so that the side marked "Prop End" is towards the front. Next install one flat plate either side down. Install the other disks and plates alternately, being sure that the disks are placed with the "Prop End" towards the front. Align the lugs on the outside diameter of the plates so that they will mesh with the slots in the rim of the clutch housing, when installed. Install the housing and secure to the attaching studs in the rear cover with six washers and castellated nuts. Do not cotterpin the nuts at this time as it may be necessary to disassemble the high speed clutch in order to adjust the intermediate impeller drive shaft end clearance.

f. Install the impeller shaft and impeller in accordance with the instructions previously given for single speed engines.

g. Place the pinions and their mating bushings in

their proper location in the anti-propeller half of the pinion cage. Install the intermediate impeller drive shaft, meshing the teeth of the pinion gears with those of the integral gear on the shaft. Assemble the front half of the pinion cage to the rear half after checking to see that the front pinion bushings and the cage aligning pins are in place. Install and tighten the cap screws which secure the two halves of the pinion cage together, placing a new tab lock under the head of each.

h. Install the impeller drive gear in its bushing in the supercharger rear housing, meshing the teeth with those of the impeller shaft gear. Place the pinion cage bushing over its journal on the impeller drive gear. Install the intermediate impeller drive shaft and pinion assembly in the impeller drive gear, being sure that the teeth of the pinion gears mesh with the internal teeth of the impeller drive gear. Install the intermediate impeller drive gear on the intermediate impeller drive shaft, mating the splines with those in the rear half of the pinion cage.

i. Install the impeller shaft thrust ring washer, the impeller shaft thrust ring, the shim, and the retainer as previously described for single-speed engines. Install the accessory drive and starter shaft.

j. Install the roller retainer or outer race on the intermediate impeller drive gear splines and install the intermediate impeller drive shaft thrust washer. Install the cam on the splines of the intermediate impeller drive shaft and install the cage and roller assembly in the retainer.

k. Install the supercharger rear housing cover and gasket temporarily, and secure with three attaching nuts and washers in each side. Remove the clearance checking plug from the rear cover. This plug is located approximately halfway between the starter and generator mounting pads. Insert the checking rod through this hole and screw into the end of the intermediate impeller drive shaft. Install the collar on the checking rod, and lock by tightening the lock screw. Screw the knurled handle on the end of the rod. Install a dial indicator on a surface gage, and adjust the position of the indicator so that the indicator spindle contacts the upper side of the collar on the checking rod. Move the intermediate impeller drive shaft up and down as far as possible by moving the checking rod, holding the knurled handle. Note the difference in the indicator readings, which is the end movement of the shaft. Insure that this end movement is greater than the minimum permissible.

l. If the end movement of the intermediate impeller shaft is too small, remove the rear cover and the high speed clutch housing and grind the required amount from the conical shaped high-speed-clutch spacer located at the front end of the high speed clutch release spring. Reassemble the high speed clutch in accordance with the instructions given previously and recheck the end movement.

m. When the proper clearance has been obtained, remove the checking rod and the supercharger rear housing cover. Cotter the nuts securing the high speed clutch housing to the rear cover. Remove the roller retainer, cam, and cage assembly to permit installation of the generator drive gear. When the acccessory gears have been installed, replace the roller retainer on the intermediate impeller drive gear. Install the cam and cage and roller assembly.

n. Install the supercharger rear housing cover on the supercharger rear housing, using fibers to assist in installing the shafts in their respective bushings in the rear cover. Secure the rear cover to the rear housing with nuts, washers, and palnuts.

o. Install the two springs on the clutch control valve stem, placing the stop washer between them. Ensure that this washer has an outside diameter of .594 in., and that the thickness of the washer is between .135 and .147 in., in order that the end movement of the valve will be properly limited. Next install the packing washer, rubber packing, and cork packing on the valve stem. Insert the valve assembly in the valve housing, being sure that the packing seats against the end of the housing. Push the valve in against the tension of the springs and install a spacer and nut on the threaded end of the valve stem. Tighten the nut against the spring tension until the valve is in the extreme out (high speed ratio) position. Slide the valve sleeve over the valve until it shoulders in the front end of the valve housing. Check to see that the three oil supply holes are not blocked. This can be done with a wire or a small light. In some assemblies, an accumulation of tolerances will allow the valve to partially block the supply holes; however, the valve will function properly if half of each hole is free. If more than half of each hole is blocked, disassemble the valve and housing and recheck the dimensions of the stop washer. Inspect the inner edge of the front land of the valve to ascertain that it has a square groove cut around it. If it does not have the groove, and interference is encountered, it will be necessary to rework or replace the valve. Recheck the assembly for interference at the oil supply hole location.

p. Remove the valve sleeve, lubricate and install it in its recess in the rear cover. Install the sleeve with the stepped end towards the rear. It may be necessary to tap

the sleeve into the rear cover with a fiber. Install a new gasket on the supercharger rear cover and install the control valve and housing assembly, being careful not to damage the valve or sleeve. When the valve has entered the sleeve, secure the housing to the rear cover with three washers, nuts, and palnuts Remove the nut and spacer from the valve stem and check the operation of the valve for full travel and freedom from binding. The desired valve travel is .98 in. and under no condition should it exceed 1.00 in.

31. GENERATOR AND MAGNETO DRIVE OIL SEALS.

a. One piece synthetic rubber oil seals will be installed in the following manner:

(1) Install the oil seal installing tool (Tool No. 803328) over the end of the generator drive shaft. Ensure that the drive shaft and the tool are clean to prevent scratching the sealing surface of the rubber oil seal.

(2) Apply AN-C-53 to the inside diameter of the rubber seal. Coat both sides of the seal gasket with a thin coating of gasket paste.

(3) Slide the gasket and the seal over the installing tool onto the shaft. The lip of the seal should be installed toward the propeller end of the engine. Refer to Figure 197. To prevent cracking of the rubber seal, ensure that it is at room temperature before it is installed. Remove the installing tool.

(4) Install the attaching screws and integral shakeproof washers, and tighten them to a torque value of 20 in. pounds. These screws supersede the screws formerly used, which were locked by a separate shakeproof washer or by the use of lockwire.

(5) Repeat the above operations for each of the magneto drive shaft oil seals.

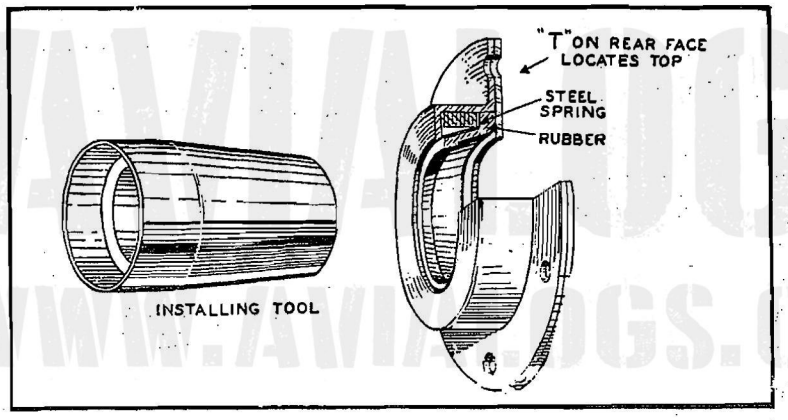

Figure 197—Magneto or Generator Drive Oil Seal and Installing Tool

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32. STARTER SHAFT SPACER, STARTER DOG, AND OIL SEAL.

a. Install the accessory drive and starter shaft aluminum spacer in position in the starter shaft. Install the starter dog over the spacer, engaging the splines in the starter dog with the internal splines in the starter shaft.

b. Using a micrometer depth gage or gage (Tool No. 800258) placed on the starter mounting pad measure the distance to the outer edge of the starter coupling jaws with the accessory drive and starter shaft and the starter dog both in the extreme forward position. Refer to Figure 198. Insure that this dimension measures 1.714 to 1.719 in. If this measurement is less than that specified, machine the required amount from the end of the spacer. It is essential that the 45° x .12 in. chamfer at each end of the spacer be maintained to avoid interference between the spacer and starter coupling, or between the spacer and oil retainer plug. Ensure that the end surfaces of the spacer are kept square and parallel within .002 in.

c. Install the oil retainer plug spring, the spacer, and the starter coupling in the shaft. Install the oil seal packing ring, a new starter coupling oil seal retainer gasket, and the oil seal retainer. Refer to Figure 199. Ensure that the gasket used measures .026 to .036 in. in thickness. Temporarily install the retainer lock screws with integral shakeproof washers, but do not bring the screws to final tightness at this time. Using a micrometer depth gage placed on the starter mounting pad as shown in Figure 200, measure the distance to the rear edge of the starter coupling jaws. Ensure that this dimension measures 1.658 to 1.684 in. If the measured dimension is less than the minimum limit, install a new oil seal packing. When the clearance is within the limits, tighten the twelve screws to a torque value of 20 in. pounds.

Paragraph d. deleted in revision dated 5 October 1945.

e. Install a substituting cover on the starter mounting pad.

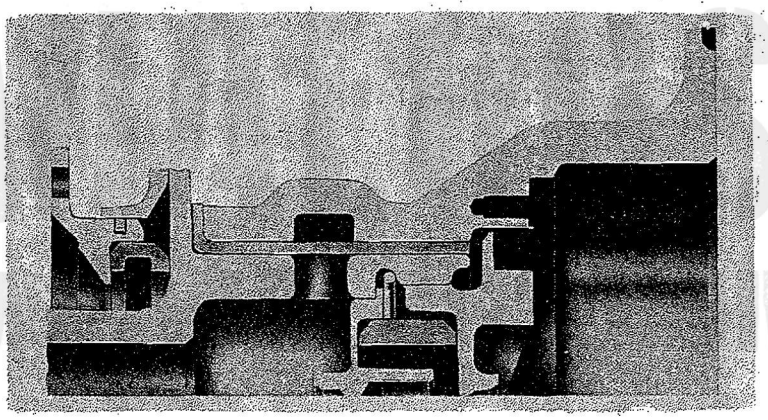

Figure 198—Starter Coupling Location—Extreme Forward Position

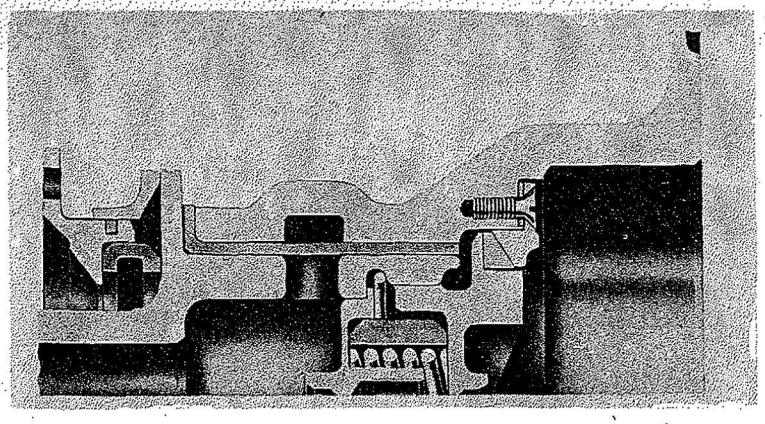

Figure 199—Starter Coupling Location—Extreme Rearward Position

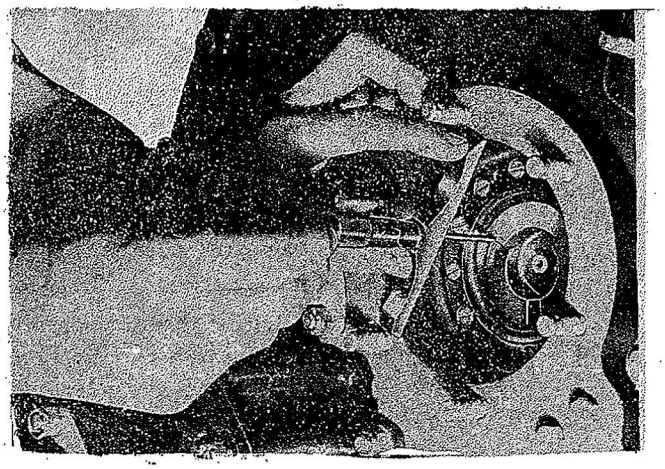

Figure 200—Measuring the Starter Coupling Locating Dimension with the Coupling in the Extreme Rearward Position

33. OIL VENT CONNECTION.

a. Install a new oil tank vent flange gasket over the oil vent connection attaching studs on the rear cover, and install the oil vent connection. Secure with flat washers, plain nuts, and palnuts. Install a pipe plug in the threads in the oil vent connection.

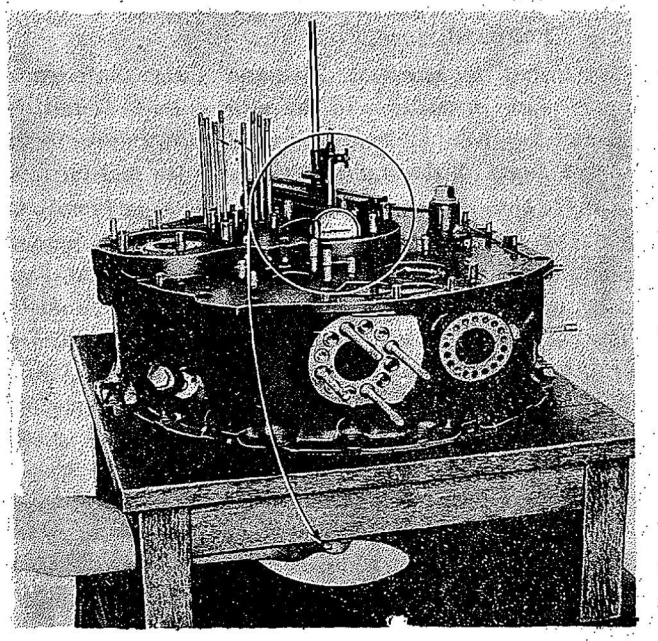

Figure 201—Checking Starter and Accessory Drive Shaft End Clearance

Figure 202 deleted in revision dated 5 October 1945.

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34. SUPERCHARGER DRAIN VALVE.

a. STANDARD TYPE.

(1) Assemble the standard type supercharger drain valve body, disk, and plug to the drain valve housing, using new gaskets between the body and housing and between the plug and the housing. Secure the plug with lock wire. Refer to Figure 203. The seating of the disk is satisfactory when not more than 5 cubic in. of gasoline per minute pass through the valve assembly, when held in an inverted position, under a suction of 5 in. of mercury. Lap the disk into the seat if necessary, using a light grade of lapping compound. Remove all traces of compound after the valve has been lapped, re-tested, and found to be satisfactory.

(2) Tighten the supercharger drain valve bushing and washer in the supercharger rear housing, and install the steel fuel venturi tube in position in the rear housing and bushing. Install the supercharger drain valve assembly in the bushing in the rear housing, inserting the outer end of the fuel venturi tube in the drain valve body.

CAUTION

Do not use excessive force when tightening this assembly into the supercharger rear housing, since that might bend the fuel venturi tube.

b. TURBO TYPE.—Place the ball check valves in position in the valve body, and insert the setscrew. Install two new rubber packing rings in the groove at the small end of the valve body and one below the flange at the large end of the valve body. If removed, insert the tube in the valve body, tap it lightly, and insure that it fits squarely in its seat. Insert the spring and valve stop in the valve housing, and with the spring compressed, install the circlet in its groove above the valve stop. Place the piston and disk unit on the valve body and assemble the valve housing to the valve body. Install the complete assembly in the supercharger rear housing, using a washer between the drain valve unit and the supercharger rear housing. Lockwire the drain valve housing to the supercharger rear housing, and install the drain line in the valve housing outlet.

35. DUAL ACCESSORY DRIVE.

a. If replacement of any of the studs in the dual accessory drive housing and cover is found to be neces-

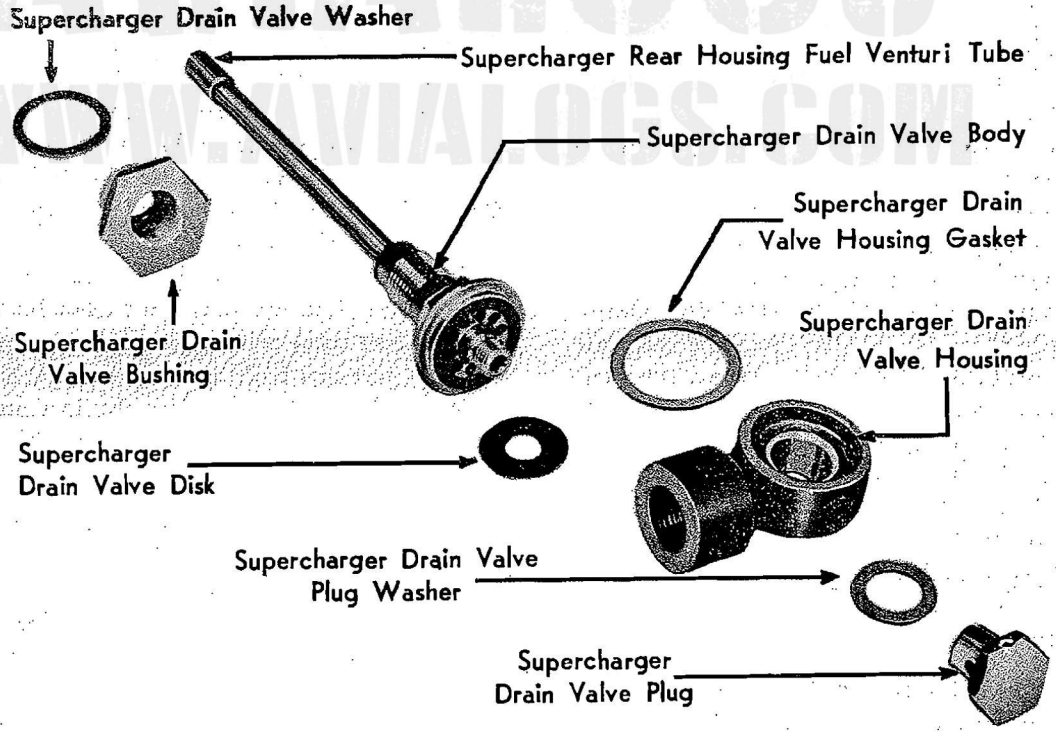

Figure 203—Supercharger Drain Valve—Exploded View

sary, do this in accordance with instructions in Section VII, paragraph 3.

b. If replacement of any of the bushings in the dual accessory drive housing and cover is found to be necessary, do this, using the set of tools (Tool No. 83168), according to the following instructions:

(1) Remove the accessory drive gear lower front bushing from the housing, using plug (Tool No. 83540-1) and collar (Tool No. 83540-2). Remove the idler gear front bushing from the housing, using plug (Tool No. 84212) and collar (Tool No. 83540-3). Remove the intermediate shaft front bushing from the housing, using plug (Tool No. 83540-2) and collar (Tool No. 83534). Remove the accessory drive gear upper front bushing from the housing, using puller (Tool No. 801226) and adapter (Tool No. 801228).

(2) Remove the accessory drive gear upper and lower rear bushings from the cover, using plug (Tool No. 82413) and collar (Tool No. 83534). Remove the idler gear rear bushing in the cover, using puller (Tool No. 801226) and adapter (Tool No. 801227). Remove the intermediate shaft rear bushing from the cover, using the same puller (Tool No. 801226) with adapter (Tool No. 801228).

(3) Bolt the adapter plate (Tool No. 83929) to the lathe face plate. True up plug (Tool No. 83929-4) to run true within .0006 full indicator reading and the upper surface of the adapter plate to run true within .001 full indicator reading. Fasten screw (Tool No. 83148-16) in the dual accessory drive housing with nut and washer (Tool No. 83148-9). Place the dual accessory drive cover on the housing. Attach the cover to the bottom plate (Tool No. 83148-1) with the engine nuts, locating the parts with plug (Tool No. 83148-10) and lock ring (Tool No. 83148-4). Assemble the top plate (Tool No. 83148-7) locating the plate with guide pins (Tool No. 83148-2). Fasten the parts with engine nut (Tool No. 83148-9), bolt (Tool No. 83148-12), and washer (Tool No. 83148-6). Use also nut (Tool No. 83148-9), stud (Tool No. 83148-8), and washer (Tool No. 83148-6). Fasten the bottom plate (Tool No. 83148-1) to the adapter plate (Tool No. 83929-1) locating the adapter plug (Tool No. 83929-4) in the bushing in the center of the bottom plate (Tool No. 83148-1).

(4) Bore the intermediate shaft front and rear bushing holes in the dual accessory drive housing and cover. To bore the other holes, shift the fixture (Tool No. 83148) to its different positions so that the holes to be bored line up with plug (Tool No. 83929-4). When reversing the fixture (Tool No. 83148) remove the plug (Tool No. 83148-10) to locate the cover on the bottom plate (Tool No. 83148-1). After removing this plug, care must be taken so that the dual accessory drive housing cover and housing are not disturbed. Bore the bushing holes in the housing and cover to the proper diameters. Refer to the Table of Limits in Section XII.

(5) Press the accessory drive gear lower front bushing in the housing, using plug (Tool No. 83540-1) and collar (Tool No. 83540-3). Press the idler gear front bushing in the housing, using plug (Tool No. 84212) and collar (Tool No. 83540-3). Press the intermediate drive shaft front bushing in the housing, using plug (Tool No. 83540-2) and collar (Tool No. 83543). Press the accessory drive upper gear front bushing in the housing, using plug (Tool No. 83540-1) and collar (Tool No. 83540-3).

(6) Press the accessory drive gear upper and lower rear bushings in the cover, using plug (Tool No. 84213) and collar (Tool No. 83534). Press the idler gear rear bushing in the cover, using plug (Tool No. 84212). Press the intermediate drive shaft rear bushing in the cover, using plug (Tool No. 83540-1).

(7) All bushings must be burnished dry. Burnish the accessory drive gear lower front bushing in the housing, using broach (Tool No. 83164) and collar (Tool No. 83540-3). Burnish the accessory drive gear upper and lower rear bushings in the cover, using broach (Tool No. 83163), collar (Tool No. 83534), and check with gage (Tool No. 83161). Place the accessory drive gear housing or cover on the lathe face plate with the bushing to be faced running square and concentric. Face the idler gear front bushing in the housing and check with gage (Tool No. 83158). Face the idler gear rear bushing in the cover and check with gage (Tool No. 83157). Face the intermediate shaft rear bushing in the cover and check with gage (Tool No. 83156).

(8) Bolt the adapter plate (Tool No. 83929) to the lathe face plate. True up the plug (Tool No. 83929-4) to run true within .0006 full indicator reading and the surface of the adapter plate (Tool No. 83929) to run true within .001 full indicator reading. Fasten the screw (Tool No. 83148-16) in the housing with the engine nut (Tool No. 83148-9) and washer (Tool No. 83148-6). Place the cover on the housing. Attach the cover to the bottom plate (Tool

No. 83148-1) with the engine nuts locating the parts with plug (Tool No. 83148-10) and lock ring (Tool No. 83148-4). Assemble the top plate (Tool No. 83148-7) locating with guide pins (Tool No. 83148-2) and fastening with engine nut (Tool No. 83148-9), bolts (Tool No. 83148-12), and washers (Tool No. 83148-6); and nut (Tool No. 83148-9), stud (Tool No. 83148-8), and washers (Tool No. 83148-6). Fasten the bottom plate (Tool No. 83148-1) to the adapter plate (Tool No. 83929) locating with adapter plug (Tool No. 83929-4) in the bushing in the center of the bottom plate (Tool No. 83148-1).

(9) Bore the intermediate shaft front and rear bushing in the housing and cover. Check with gage (Tool No. 83159-front, Tool No. 83162-rear). Turn the flange outer diameter of the intermediate shaft front bushing in the housing and check the outer diameter with gage (Tool No. 83138). Remove the fixture with the work in position with the adapter. Fasten the bottom plate (Tool No. 83148-1) to the adapter plate (Tool No. 83929) locating with adapter plug (Tool No. 83929-4) in the bushing near the plug in the center of the bottom plate. Bore the idler gear front and rear bushings in the housing and cover. Check with gage (Tool No. 83160). Remove the fixture from the adapter plate with the work in position. Remove the plug (Tool No. 83148-10) which locates the cover on the bottom plate. Remove the engine nuts and screw and washers (Tool No. 83148-12, -6). Remove the cover without unclamping the housing from the top plate. Care must be taken in removing the cover so that the setting of the housing on the top plate is not disturbed. Replace the screw and washers (Tool No. 83148-12, -6), with screw and washer (Tool No. 83148-14, -6). Fasten the top plate (Tool No. 83148-7) to the adapter plate (Tool No. 83929) locating the part with adapter plug (Tool No. 83929-4) in the bushing (Tool No. 83148-13) of the top plate. Bore the accessory drive upper gear front bushing in the housing and check with gage (Tool No. 83159).

(10) Break all sharp corners 1/64 in. and clean out all oil holes.

CAUTION

Some of the bushings in the dual accessory drive housing and cover are of the sintered type. Do not attempt to ream, scrape, or hand burnish these bushings. Broaching the inside diameter to size is the only recommended method.

c. Before assembly of the dual accessory drive housing to the supercharger rear housing cover, insure that the oil pressure and drain holes in the dual accessory drive housing mounting pad on the rear cover are clear.

d. Clean the dual accessory drive housing mounting pad on the rear cover thoroughly, and install a new gasket in this location, over the attaching studs. Insure that the small oil hole in the gasket is punched out and indexes properly with the oil drain hole in the rear cover.

e. Place the dual accessory drive housing in position over the attaching studs in the rear cover, and install the nuts and washers in recesses in the housing. Tighten these nuts, using the offset box wrench (Tool No. 800684) for the two 5/8 in. hexagon nuts. Lockwire the nuts, being careful to lockwire in such a way that the wire will not interfere with the operation of the driving gears, when installed. Install and tighten the extended nut and washer on the rim of the housing at the upper right corner. Lockwire the nut. Install the two copper washers and acorn nuts on the attaching studs extending through the rim of the supercharger rear housing and rear cover. Tighten and lockwire these nuts.

f. Lubricate the bushings in the dual accessory drive housing thoroughly with corrosion preventive mixture. Assemble the dual accessory drive intermediate gear to the idler gear, using the proper cap screws, and wrench (Tool No. 82914). The proper cap screws for use in this location are 3/8 in. long, measured from the underside of the head to the end of the screw. Lubricate and install the dual accessory drive idler gear, the dual accessory driving gear, and the upper and lower drive gears in their respective bushings. Insure that all gears are properly meshed. Refer to Figure 204.

g. Install a new gasket over the attaching studs on the rim of the dual accessory drive housing. Lubricate the bushings in the dual accessory drive housing cover, and install the cover on the housing. Install and tighten two washers and 7/16 in. hexagonal head extended nuts on the upper rim of the cover. Lockwire the nuts. Install new gaskets on the accessory drive mounting pads. Install the upper and lower accessory drive substituting covers, and secure with flat washers, plain nuts, and palnuts.

36. OIL PUMP.

a. Install the oil pump drive gear shaft in the proper

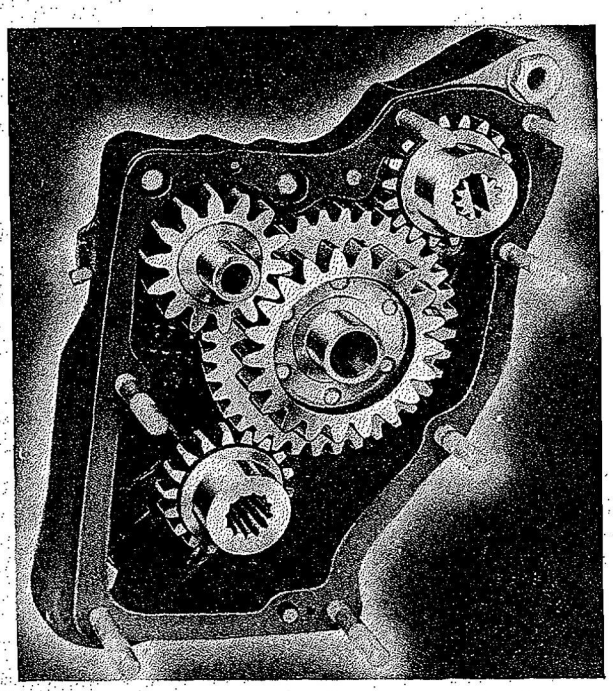

Figure 204—Dual Accessory Drive Gears

hole in the oil pump front end plate, and install the oil pump coupling gear, washer, and nut on the end of the shaft. Tighten the nuts while holding the coupling gear using wrench (Tool No. 82676).

b. Tighten all oil passage plugs in the oil pump body, after insuring that the passages are clear. Install the oil suction pump idler gear shaft and the suction pump idler gear in position in the recess in the oil pump body. Install a new gasket on the front end of the oil pump body. Place the oil pump end plate in position on the gasket, meshing the oil suction pump drive gear with the idler gear and inserting the end of the idler gear shaft in the hole provided for it in the front end plate. Install a new gasket over the oil pump attaching studs on the rear cover. Place the oil pump drive gear spring in the plug in the oil pump drive gear. Install the oil pump body and front end plate over the attaching studs on the rear cover, engaging the splines on the coupling gear with the internal splines in the oil pump drive gear. Insure that the oil pump drive gear spring is seating properly on the shoulder on the oil pump drive coupling nut. Insure that the attaching lug on the foot of the oil pump body is installed on the stud on the rim of the rear cover.

c. Install the oil pressure pump drive gear in the recess in the oil pump body, over the splines in the end of the oil pump drive gear shaft. Install the mating idler gear. Lubricate all parts thoroughly. Install a new gasket and the oil pump rear cover. Secure the oil pump front end plate, oil pump body and oil pump rear cover to the supercharger rear housing cover by installing flat washers and castellated nuts on the eight attaching studs which project through the rim of the cover. Tighten the nuts to the proper torque value and secure with lock wire. Install a flat washer and the special nut on the stud on the rim of the supercharger rear housing cover, securing the lower part of the oil pump body. Tighten the nut using wrench (Tool No. 800684) and secure with lock wire.

d. Place a new gasket over the two oil pump studs, and install the tachometer drive gear housing. Install the tachometer drive gear oil seal ring and retainer over the front end of the tachometer drive gear shaft. Install the drive gear, oil seal ring, and retainer in the housing, engaging the splines on the shaft with the internal splines in the oil pressure pump drive gear. Place the mechanical and electric tachometer drive gears in position in the housing, meshing these gears with the drive gear. Install oil seal rings over these two drive gear rear extensions, and install the two retainers. Lubricate these parts thoroughly.

e. Install a new gasket on the tachometer drive gear housing, and install the tachometer drive gear housing cover. Install and tighten the cap screws and flat washers which attach the tachometer drive gear housing and cover to the oil pump rear cover. Secure the cap screws with lock wire.

f. Install new gaskets on the mechanical and electric tachometer mounting pads. Install the mechanical tachometer drive shaft housing, and secure with two flat washers, plain nuts, and palnuts. Install the protecting cap over the threads on the end of the housing. Install the electric tachometer substituting cover, and secure with four flat washers, plain nuts, and palnuts.

g. Install the oil pressure relief valve body in the oil pump body using wrench (Tool No. 83660). Lubricate and install the valve, spring, and adjusting screw. Place a shouldered bronze washer over the adjusting screw, and install the lock nut. Screw the oil pressure adjusting screw approximately half way in, and tighten the lock nut. Install the other shouldered bronze washer and relief valve cap on the end of the adjusting screw. Secure the cap with lock wire.

h. Final adjustment of the oil pressure relief valve

is made during engine test after final assembly. Refer to Section X.

i. If an oil check valve is used, install the valve with ring, spring, a new gasket, and the retainer. If the oil check valve is removed, insert an aluminum plug in the check valve body, and install a new gasket and the retainer. Lockwire the retainer.

j. Install new gaskets over the inlet and outlet flange attaching studs. Install the oil inlet and outlet flanges, and secure with flat washers, plain nuts, and palnuts. Tighten pipe plugs into the tapped holes in the flanges temporarily.

k. Install the oil temperature thermometer connection bushings in the oil pump body. Install gaskets and plugs in the bushings, and secure with lock wire.

37. GUN SYNCHRONIZERS, DRIVE SHAFTS, AND SUPPORTS.

a. If replacement of the gun synchronizer impulse generator drive shaft support bushings is found to be necessary, do this in accordance with instructions in Section VII, paragraph 41.

b. Assemble each gun synchronizer impulse generator, drive shaft, and support in the following manner: Coat the drive shaft and the support bushings with clean engine oil. Insert the drive shaft in the support so that the threaded end of the shaft extends through the flanged end of the support. Install the cam and nut assembly on the shaft, and tighten the nut to the specified torque value using wrench (Tool No. 82848). Refer to the Table of Limits in Section XII. Cotter the nut, bending one end of the cotter pin over the nut, and the other end flush across the end of the shaft.

c. Insert the plunger into the lower housing, engaging the spline in the end of the plunger with the spline in the lower part of the housing. Place a new gasket on the drilled mounting face of the housing and place the assembled drive shaft support, shaft, and cam in position on this mounting face. Turn the shaft if necessary to bring the cam in position so that it may pass through the hole in the plunger. Insure that the drilled holes in the housing, gasket, and support are aligned. Temporarily secure these parts together by inserting the three washers and cap screws and installing a nut on each cap screw.

d. Install the laminated shim over the three studs on the top of the lower housing over the end of the plunger and the gasket. Secure with flat washers and castellated nuts.

e. Screw the plunger lock into position in the upper plunger housing, insuring that the end of the lock seats properly in the notch in the plunger. Remove the inspection plug from the side of the lower plunger housing and check the clearance between the cam lobe and the roller follower on the plunger. Refer to the Table of Limits in Section XII. If this clearance is not within the specified limits, add or remove shims from the laminated shim under the upper plunger housing until the proper value is obtained. When the clearance is satisfactory, reinstall the inspection plug and gasket, and lockwire the plug. Tighten the castellated nuts on the upper plunger housing attaching studs to the proper torque value, and secure with lock wire. Install the gun control cable replacement cover on the threads on the upper housing.

f. Check the end movement of the gun synchronizer drive shaft by applying pressure on the nut end of the shaft and measuring the clearance between the spiral gear and the shoulder on the front bushing. Refer to the Table of Limits in Section XII. If this clearance is too small, machine metal from the bushing shoulder to obtain the proper clearance. If this clearance is too large, it will be necessary to install a new bushing. If the clearance is satisfactory, install the plug and gasket in the lower housing at the end of the shaft, and lockwire the plug.

g. Install each gun synchronizer impulse generator, drive shaft, and support assembly in the supercharger rear housing and cover assembly in the following manner: Remove the nuts, cap screws, and washers temporarily attaching the gun synchronizer drive shaft support to the lower plunger housing. Place a new gasket on the gun synchronizer mounting pad on the supercharger rear housing, and install the gun synchronizer assembly in the rear housing. It may be necessary to rock the assembly slightly to mesh the gears. Insure that the attaching cap screw holes in the lower plunger housing, drive shaft support, supercharger rear housing, and gaskets are aligned. Install the three cap screws, tighten to the proper torque value, and lockwire securely.

h. It is necessary to "time" the gun synchronizer impulse generator system after the engine is installed in the airplane. Instructions for obtaining this timing are not included in this manual.

38. GUN SYNCHRONIZER SUBSTITUTING COVERS.

a. If gun synchronizer impulse generators are not used in the engine, install the gun synchronizer im-

pulse generator substituting covers. These covers are provided with a flange which is installed on the mounting pad on the supercharger rear housing, and an integral, horizontal extension which serves to plug the hole in the supercharger rear housing cover, located directly behind the mounting pad on the rear housing. Install and tighten the three cap screws and washers which secure each substituting cover to the rear housing, and lockwire the cap screws.

39. CUNO OIL FILTER.

a. Install the filter on the supercharger rear housing mounting pad, using a new gasket between the filter and the housing. To prevent damaging the exposed filter cartridge, exercise care not to strike the cartridge against the sides of the filter hole. If the filter does not enter its location readily, do not attempt to force it into place. Check to determine the cause of the tight fit before attempting to install the filter again. When the installation has been correctly made, install, tighten, and lockwire the three nuts. Lockwire the manual turning nut to the tab on the special lock washer beneath it. Refer to Figure 205.

39A. PRESSURE OIL STRAINER.

a. Place the oil screen assembly in its housing and turn it until the large dowel at the end of the screen enters the hole in the end of the housing. Install a washer on the hex head retaining screw and insert the screw through the hole in the center of the strainer cover. Locate the cover against the end of the screen and housing, guiding it by the dowel. Run the hex head screw down into the screen assembly. Lockwire the screw to the tab provided on the face of the cover. Refer to figure 205A.

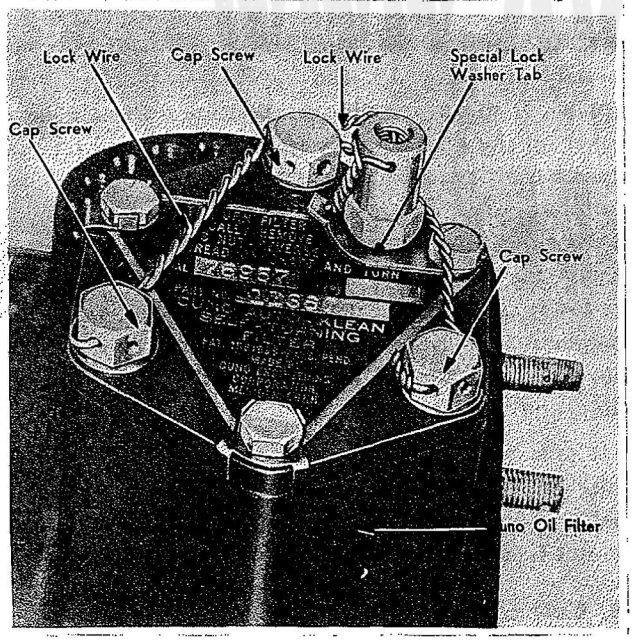

Figure 205—Method of Lockwiring Cuno Oil Filter

b. Place a new rubber seal in the groove on the ID of the strainer cavity in the supercharger rear cover. Coat the ID of the seal lightly with anti-seize compound, Specification JAN-A-669. Install the strainer assembly through the opening provided in the supercharger rear housing. Observe the unequal spacing of the mounting studs and position the strainer assembly accordingly, install the washers and run down the attaching nuts on the studs. Tighten the nuts and lockwire them to each other.

40. FUEL PUMP DRIVE.

a. Prior to installing a new fuel pump drive shaft oil seal, check the inside diameter of the support recess and the outside diameter of the seal to insure proper fit. Refer to the Table of Limits in Section XII. In the event the required fit of the seal cannot be obtained, another seal should be selected and tried for proper fit.

b. Install the seal in the fuel pump drive shaft support so that the leather lip on the seal faces inward. Use tool No. 801225 to press the seal into position.

c. Use tapered plug (Tool No. 801719) in the end of the shaft when installing the shaft in the support to prevent damaging the seal.

d. Coat the fuel pump drive shaft and support bushings with clean engine oil. Insert the fuel pump drive shaft in the support so that the splined end of the shaft extends through the flanged end of the support. Install the fuel pump drive shaft and support assembly in the supercharger rear housing and cover assembly, using a new gasket between the support and the rear housing. It may be necessary to turn the shaft slightly in order to mesh the gears. Install the fuel pump substituting cover gasket and cover. Install and tighten four flat washers and castellated nuts on the fuel pump attaching studs. Secure the nuts with lock wire.

41. CRANKSHAFT FRONT AND REAR MAIN BEARINGS.

a. For instructions regarding the repair and handling of the crankshaft front and rear main bearings, refer to Section VII, paragraph 4.

42. CRANKSHAFT FRONT END.

a. Before assembling the crankshaft, master rod, and articulated rods refer to paragraph 1 of this section.

b. Before assembling the front counterweight to the

crankshaft front end, coat the inside diameter of the counterweight bushings and the crankshaft front end bushings thoroughly with AN-C-53. Install the front counterweight on the crankshaft front end so that the front crankshaft cheek extends into the slot in the counterweight.

CAUTION

Insure that the end of the counterweight which is marked "PROPELLER END" is facing the front of the crankshaft.

c. Thoroughly coat the counterweight pins with AN-C-53. Hold the counterweight in position and install the counterweight pins. Install the front counterweight stop plate on the front face of the

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crankshaft cheek, and secure with two bolts and nuts. Tighten the nuts and secure with cotter pins.

d. Coat the crankpin front plug with AN-C-53 and install in the crankpin. Insure that the hole in the plug is aligned with the tapped hole in the crankshaft. Install a new tab lock and the crankpin front plug locking cap screw. Tighten the cap screw and bend up the tab lock to secure it.

e. Install the crankcase front end in the assembly and disassembly fixture (Tool No. 800710, mounted on floor stand, Tool No. 800711). Tighten the two clamps on the fixture to hold the crankshaft firmly in the fixture, with the counterweight in the downward position.

f. Coat the breather tube rear support or substituting plug, whichever is used, with AN-C-53, or its equivalent, and install in the crankshaft cheek. Insure that the hole in the plug is aligned with the tapped hole in the crankshaft. Install a new tab lock and the locking cap screw. Tighten the cap screw and bend up the tab lock to secure it.

43. CRANKSHAFT REAR END.

a. Before assembling the rear counterweight to the crankshaft rear, coat the inside diameter of the counterweight bushings and the floating crankshaft rear end bushings thoroughly with AN-C-53, or its equivalent. Install the rear end bushings in the bronze bearings on the crankshaft rear end so that the rear crankshaft cheek extends into the slot in the counterweight.

CAUTION

Insure that the end of the counterweight which is marked "ANTIPROPELLER END" is facing toward the rear of the crankshaft.

b. Thoroughly coat the counterweight pins with AN-C-53, or its equivalent. Hold the counterweight in position and install the counterweight pins. Install the rear counterweight stop plate on the rear face of the crankshaft rear, and secure with two bolts and nuts. Tighten the nuts and secure with cotter pins.

c. Install the starter shaft coupling in the crankshaft rear, engaging the external splines on the coupling with the internal splines in the crankshaft rear extension.

44. ASSEMBLY OF MASTER ROD AND ARTICULATED RODS.

a. WITH LOOSE SILVER BEARING.

(1) Install a silver bearing after installing the knuckle pins. Apply oil generously to the bearing and install so that the spline tooth marked with an ellipse is located between the ellipse marked teeth of the locking plate. If the bearing does not slip in easily, due to slight out-of-round condition, do not force it into the master rod bore. Heat the master rod in an oil bath at 93° C (200° F) for 1/2 hour, then swab the outside diameter of the cold bearing with engine oil and it should slip easily into the master rod. Make sure the proper slotted end seal spacer is used in conjunction with prefit bearings. Check the oil metering jets before installing the spacer so as to keep the oil flow within proper limits.

b. WITH TIGHT FIT BEARING.

(1) Before assembling the articulated rods to the master rod, coat the knuckle pin holes in the master rod with AN-C-53, or its equivalent, and coat the knuckle pin bushing in the articulated rods with clean engine oil.

(2) Knuckle pins are marked with the number of the cylinder in which they were originally installed. These parts must be installed in their original position. If new parts are used, identify them for proper position.

(3) The knuckle pins must be assembled in the master rod so that the side of the step in the small end of each knuckle pin will mate with the squared end of the lugs in the knuckle pin locking plate, upon installation of the locking plate. Provision is made in the knuckle pin assembly and disassembly fixture (Tool No. 83913-1) to properly locate the knuckle pins in this manner. Another means must be used to properly locate the knuckle pins when the fixture (Tool No. 83913-1) is used, and this will be described in a following paragraph. (Tool No. 83913 is a set of tools, and includes all tools necessary for removal and installation of knuckle pins. Tool No. 83913-1 is a fixture, used in connection with wedges, Tool No. 83913-19, and plugs, Tool No. 83913 -20 and -21, for performing the same operations.)

(4) To install knuckle pins using the set of tools (Tool No. 83913), place the master rod on the fixture (Tool No. 83913-1) with the bearing flanged end

down and with the spring-loaded locating pin on the fixture projecting into a knuckle pin hole. The two locating blocks which bear on the master rod hub, one on each side of the rod, locate the master rod correctly in the lateral direction. Clamp the master rod in this position. Place the fixture and rod on the arbor press table and locate the spring-loaded pin on the fixture directly under the arbor. Push down the locating pin on the fixture and install the proper articulated rod in position over the locating pin. Place a knuckle pin in position in the master rod so that the step on the end of the knuckle pin mates with the step in the locating pin. Insert the two wedges (Tool No. 83913-19) between the flanges of the master rod on each side of the articulated rod. Press in the knuckle pin, using the installing lug (Tool No. 83913-21) under the arbor, fitting the boss on the plug in the bore in the end of the knuckle pin. When the locating pin bottoms in the fixture, the small end of the knuckle pin will be within the required limits of flush to .002 in. above flush with the front face of the master rod front flange.

(5) Install all knuckle pins in this manner.

(6) To install knuckle pins using the fixture (Tool No. 83913-1), first locate the knuckle pins in the master rod so that the step in the knuckle pins will mate properly with the lugs in the knuckle pin locking plate. To do this, install the knuckle pin locking plate temporarily on the front of the master rod, engaging the splines on the inside diameter of the locking plate with the splines of the master rod bearing flange. Install one articulated rod and its knuckle pin in the proper position in the master rod by hand. Place a metal rule approximately 5/8 in. wide over the squared end of the lug on the locking plate so that the end of the rule contacts the end of the knuckle pin. Turn the knuckle pin until the side of the step in the end of the rule contacts the end of the knuckle pin, the rule is flat against the end of the lug on the locking plate. Tap the knuckle pin into the master rod, using a fiber mallet just far enough so that the pin is tight in the rod. Repeat this procedure for each of the other knuckle pins and articulated rods. When all of the knuckle pins have been installed in this manner, remove the knuckle pin locking plate.

(7) Place the master and articulated rod and knuckle pin assembly on the fixture (Tool No. 83913-1) on an arbor press table, with the stepped end of the knuckle pins down. Insert two wedges (Tool No. 83913-19) between the flanges of the master rod on each side of the one articulated rod. Press the knuckle pin into the master rod until the front face of the pin bottoms on the fixture. Insure that the knuckle pin being pressed in is not over the hole in the base. Installing plug (Tool No. 83913-20) is used under the arbor for this pressing-in operation. Refer to Figure 206.

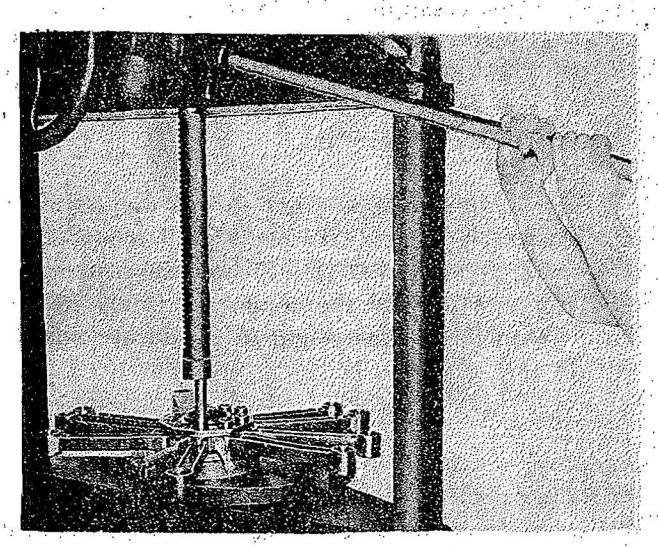

Figure 206—Pressing In Knuckle Pins

(8) Press in all knuckle pins in this manner.

(9) Do not under any circumstances drive knuckle pins into or out of master rods, using a drift and hammer. Hammer blows on the hardened surface of a knuckle pin during assembly might start small cracks, which, under operating conditions, could enlarge to cause failure of the knuckle pin.

(10) Complete the assembly of the master rod in the following manner: Install the knuckle pin locking plate in position on the front end of the master rod, engaging the splines on the inside diameter of the locking plate with the splines on the master rod bearing flange. Check to insure that the squared ends of the lugs on the locking plate mate with the flat side of the step on the knuckle pins. Install new tab locks and the knuckle pin locking cap screws. Tighten the lock screws and bend up the tab locks to secure them.

Figure 207—Deleted in revision dated April 15, 1944

(11) Place the master rod end seal disk in position in the locking plate, engaging the lugs on the disk with those on the locking plate.

(12) It is necessary to install the crankshaft rear temporarily on the crankpin to determine the proper oversize master rod end seal spacer to be used. Install the

crankshaft rear spreader plug (Tool No. 84765-1) in the unthreaded end of the cap screw hole, and install the plate (Tool No. 84765-2) in the slot in the plug so that the plate contacts the side of the clamp joint. Tighten the screw (Tool No. 84699) in the threaded end of the cap screw hole, forcing the plate against the side of the clamp joint and spreading the crankshaft rear. Do not spread the crankshaft rear any more than is necessary to permit installation on the crankpin.

(13) Assemble the crankshaft rear on the crankpin, with the crankshaft front end held in the assembly and disassembly fixture, so that the over-all measurement from the front main bearing shoulder to the rear main bearing shoulder is 7.062 in. Refer to Figure 208. Loosen the spreader screw, allowing the crankshaft rear to clamp onto the crankpin. Measure the distance between the shoulder at the crankpin fillet and the front face of the crankshaft rear, using an inside micrometer. Refer to Figure 209. From this measurement, subtract the original measurement between these surfaces, which is 3.562 in. when new parts are used. This figure represents the amount of material removed from the crankshaft surfaces. Add to this figure the amount of material found to be removed from the master rod, determined previously. The sum of these figures is the oversize spacer required for use when the crankshaft is assembled. Master rod end seal spacers are provided in oversize thickness of .005 in., .010 in., .020 in., .030 in., .040 in., and .050 in.

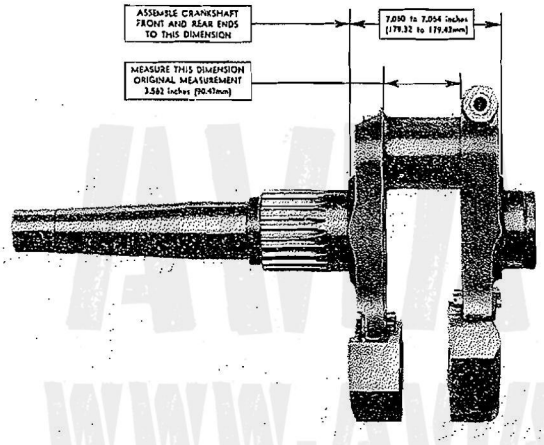

Figure 208—Crankshaft Assembly Dimensions

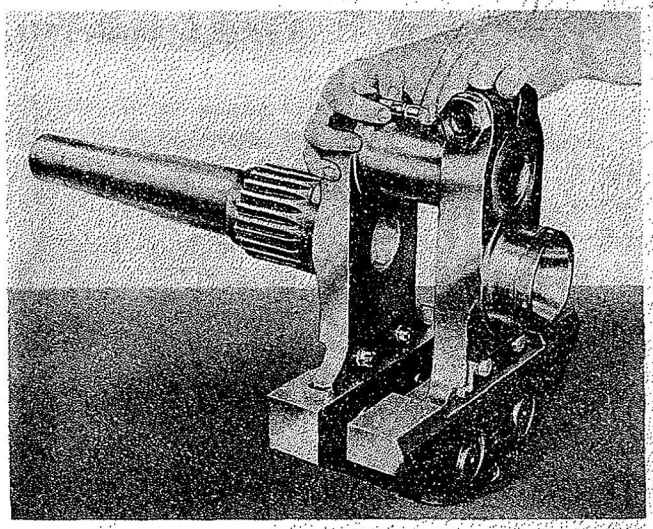

Figure 209—Measuring Distances from Crankpin Fillet to Front Face of Crankshaft Rear

(14) When it has been determined which oversize master rod end seal spacer is required, remove the crankshaft rear from the crankshaft front end.

45. CRANKSHAFT ASSEMBLY.

a. Wash the crankpin thoroughly with gasoline, dry in an air blast, and lubricate freely with corrosion preventive mixture. Lubricate the inside diameter of the master rod bearing with corrosion preventive mixture.

EXAMPLE

Measured distance between crankpin shoulder and crankshaft rear	3.575 in.	
Subtract original measurement between crankpin shoulder and crankshaft rear	3.562 in.	
(A) Material removed from crankshaft surfaces		0.013 in.
Original width of master rod hub	3.167 in.	
Subtract measured width of master rod hub	3.160 in.	
(B) Material removed from master rod hub		0.007 in.
Oversize spacer required = (A) + (B)		0.020 in.

Figure 210 deleted in revision dated 5 October 1945.

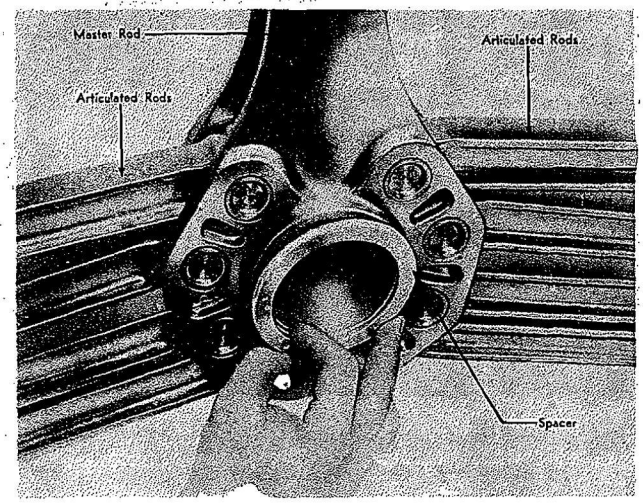

Figure 211—Installing Master Rod Spacer

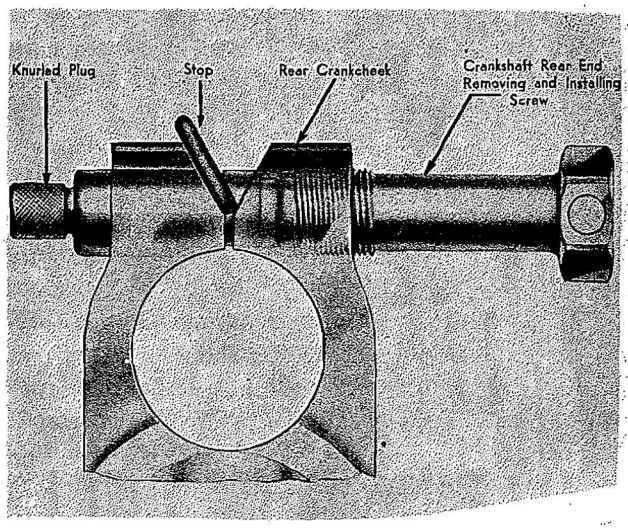

Figure 212—Tool for Spreading Rear Crankcheek

Install master rod oil seal disk in the knuckle pin locking plate. Figure 210 deleted in revision. Hold the master rod in a vertical position and group four articulated rods on both sides of the master rod together, holding each group of rods together with a heavy rubber band. With the crankshaft front end clamped in the crankshaft assembly and disassembly fixture, install the master and articulated rod and end seal assembly on the crankpin. Install the proper oversize spacer over the rear end of the master rod hub. Refer to Figure 211. Push the master and articulated rod and end seal assembly forward on the crankpin until the end seal disk is contacting the shoulder at the front end of the crankpin.

b. Install the crankshaft rear end on the crankpin, using the spreader plug (Tool No. 84765-1), plate (Tool No. 84765-2), and screw (Tool No. 84699) in the same manner as previously described for the use of these tools. Refer to Figure 212. Insert a feeler gage of the proper thickness between the master rod end seal spacer and the crankshaft rear. Refer to Figure 213. Push the crankshaft rear forward on the crankpin until the feeler gage is held firmly between the two parts, thus insuring that the proper master rod end movement is obtained. Refer to the Table of Limits in Section XII. Turn the crankshaft rear on the crankpin until the smallest of the selective fit align-

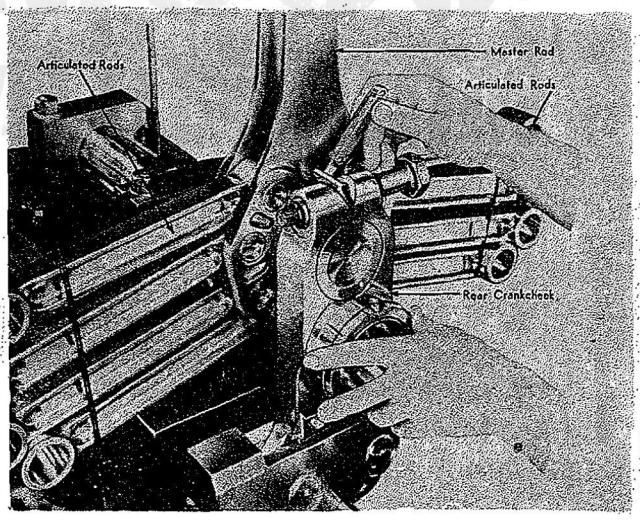

Figure 213—Measuring Clearance Between Master Rod and Rear Crankcheek

ing bars (Tool No. 80443) may be inserted through the holes in the crankshaft front and rear counterweights, and remove the installing tools. Lubricate the threaded portion of the clamping cap screw hole in the crankshaft rear with AN-C-53, or its equivalent, and install the chamfered washer and clamping cap screw finger tight.

CAUTION

Insure that none of the lubricant is deposited on the crankpin clamping surface, since this will seriously impair the clamping action of the crankshaft rear. If this condition is encountered, disassemble the parts, clean thoroughly, and reassemble as previously outlined.

c. Align the crankshaft rear end to the crankshaft front end in the following manner: Insert the medium and largest selective fit aligning bars (Tools No. 83576 and 83577, respectively) through the holes in the crankshaft front and rear counterweights. Tap the side of the crankshaft rear, using a fiber or hard rubber mallet until this part is aligned with the crankshaft front end, when the largest selective fit aligning bar (Tool No. 83577) is used. Refer to Figure 214.

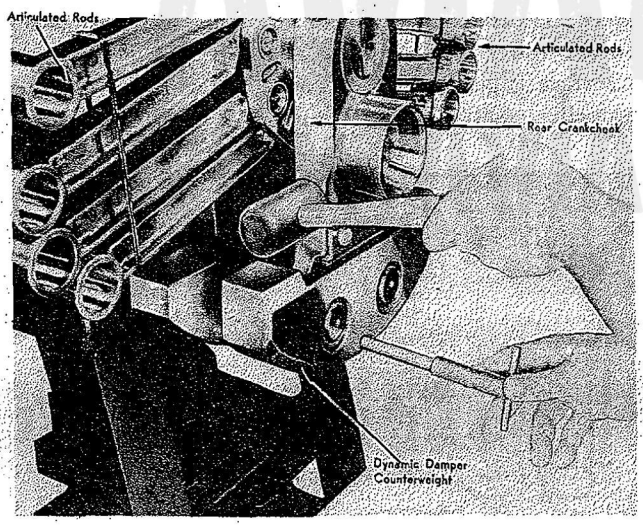

Figure 214—Aligning Crankshaft Rear

The position of best alignment may be determined by the ease with which the aligning bar may be inserted in the holes. Binding of the bar upon insertion indicates misalignment of the parts.

CAUTION

Do not tap the crankshaft rear when the aligning bar is inserted in the crankshaft front end, as this may bend the bar.

d. Before tightening the clamping cap screw, with the cap screw finger tight in the crankshaft rear, install the cap screw stretch measuring tool (Tool No. 82200) on the ends of the cap screw. The balls on the tool contact the chamfered sides of the counterbores in the ends of the screw. Using a micrometer installed over the balls, measure the distance between the outer ends of the balls. Refer to Figure 215. This dimension must be known in order to determine the cap screw stretch after tightening.

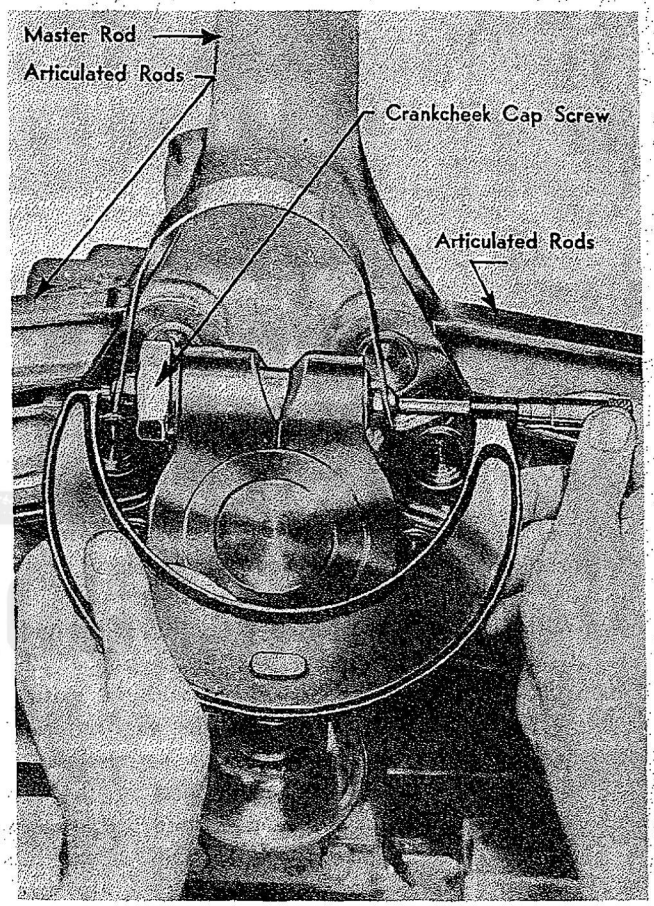

Figure 215—Measuring Rear Crankshaft Cap Screw Stretch

e. Tighten the knurled head bolt underneath the crankshaft rear counterweight to support the crankshaft during the following operations: Tighten the lock nut on the bolt to lock the bolt in the proper position. Tighten the crankshaft rear clamping cap screw, using wrench (Tool No. 80309) and extension (Tool No. 80198), until the proper cap screw stretch is obtained, at the same time aligning the cotter pin hole in the threaded end of the cap screw with its mat-

ing hole in the crankshaft rear. Refer to Figure 216. Reinstall the stretch measuring tool over the cap screw and measure the distance between the outer ends of the balls as before. The cap screw stretch is the difference between the two micrometer readings. Insure that the stretch is within the proper limits. Refer to the Table of Limits in Section XII.

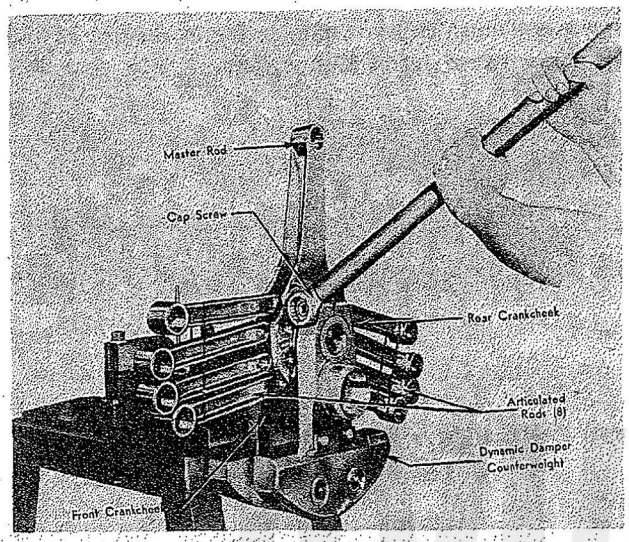

Figure 216—Tightening Rear Crankshaft Cap Screw

f. Lock the cap screw by inserting the cotter pin in the cap screw from the inside of the cap screw at the threaded end, allowing it to protrude through the crankshaft rear approximately 3/8 in. Refer to Figure 217. Bend down the legs of the cotter pin. If the hole in the cap screw is not aligned with its mating hole in the crankshaft rear when the cap screw is tightened to the proper stretch, it is permissible to drill a new cotter pin hole in the end of the cap screw. Insure that the new hole is located a minimum distance of 1/4 in., measured at the root of the cap screw thread, from any adjacent hole. It is also permissible to grind either face of the chamfered cap screw washer in order to locate an undrilled portion of the cap screw under the cotter pin hole in the crankshaft rear. If this is done, break all sharp edges to a 1/64 in. radius after grinding.

g. At this time, recheck the master rod end movement by inserting a feeler gage between the master rod end seal spacer and the crankshaft rear, when the master and articulated rod assembly is in the extreme forward position.

h. Install the crankshaft rear main bearing as follows: Heat the rear main bearing inner race for 10 minutes in an oil bath maintained at a temperature of 107 deg C (225 deg F), and install over the crankshaft rear extension. Insure that the lip on the outside diameter of the inner race is facing toward the crankshaft rear cheek. Tap the rear end of the inner race after installation to insure that it is bottomed on the shoulder on the crankshaft rear end.

i. Install the crankshaft rear main bearing outer race, retainer, and rollers on the inner race. Insure that the side of the outer race marked "PROPELLER END" is facing toward the crankshaft rear cheek. Install the crankshaft rear main bearing retaining nut. Tighten the retaining nut to the torque value of 1100-1300 inch-pounds. Secure the nut provided the correct torque exists. If alignment of the locking pin holes cannot be obtained, continue tightening, using a torque wrench or as shown in figure 218, until the crankshaft and the nut locking pin holes are aligned. Do not exceed a turn of 20 degrees. Install a new tab lock and rear main bearing nut locking cap screw or tighten the lock screw and bend up the tab lock to secure it.

j. Remove the crankshaft assembly from the assembly and disassembly fixture and install on two alignment checking rollers (Tool No. 802694), in order to check the crankshaft alignment. Turn the crankshaft on the rollers and using a dial indicator mounted on a surface gage, check the runout at the front and rear propeller shaft housing journals on the crankshaft.

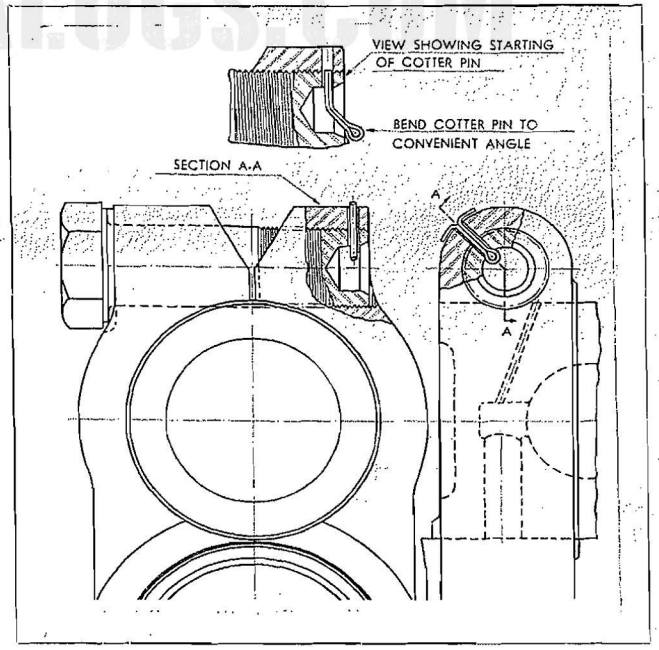

Figure 217—Cotterpinning Rear Crankshaft Cap Screw

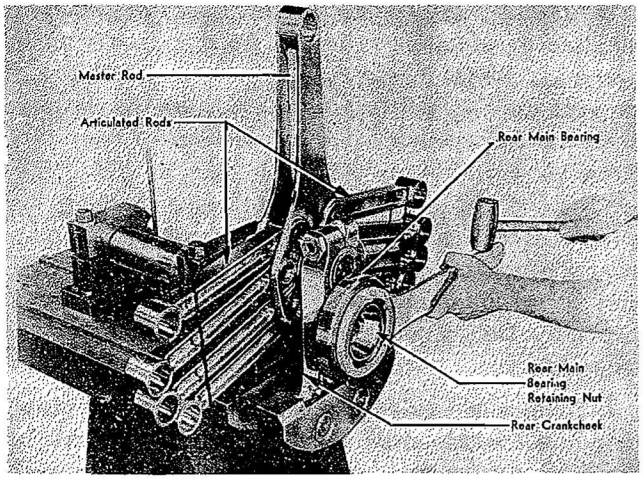

Figure 218—Tightening Rear Main Bearing Retaining Nut

Refer to the Table of Limits in Section XII for the allowable runout at these locations. If the crankshaft runout is not within the specified limits, the crankshaft alignment is not sufficiently accurate. If this condition is encountered, it will be necessary to reassemble the crankshaft to obtain proper alignment as determined by the runout check on the rollers.

k. At this time, check also the clearance between the shank of the master rod and the front surface of the rear counterweight or counterweight pins, whichever is closer to the rod. When making this check, hold the master rod in the extreme rear position on the crankpin, with the end seal spacer contacting the crankshaft rear. The minimum permissible clearance in this location is .038 in.

46. VALVE ASSEMBLY.

a. Lubricate the valve stems with corrosion preventive mixture. Put both valves in place in the cylinder and place the cylinder on the assembly block (Tool No. 80262). Install the lower valve spring washers around each valve guide. Place the inner, intermediate, and outer valve springs in place on the lower washers and the upper valve spring retainer washers on the top of the springs. Compress the valve springs using the valve spring compressor (Tool No. 81409) and install the valve locks. Make certain that the locks are properly located in the valve stem groove.

b. Temporarily install the rocker arms and check for interference between the under side of the rocker arms and upper valve spring washers or the outside diameter of the outer valve springs. If interference exists, use a valve spring washer which has a .010 in. undersize bore. This washer, when assembled on the valve and split locks, is seated .048 in. farther from the stem end of the valve than the standard washer, thus reducing the tendency for the rocker arms to interfere with the outer valve spring or valve spring upper washers.

c. Whenever a valve spring washer having an undersize bore is used, make the following check to insure that bottoming of the valve springs cannot occur: Measure the distance from the stem end of the valve to some convenient reference point on the cylinder, such as the rocker box cover mounting flange. Open the valve as far as possible, compressing the valve springs, and measure again the distance from the end of the valve to the same reference point. If the valve travel, which is the difference between these two measurements, is greater than .650 in. valve spring bottoming cannot occur. If the valve travel is less than .650 in., it is highly probable that valve spring bottoming will occur during engine operation. In cases where the valve travel is found to be less than .650 in., it is recommended that new valve springs be used in the assembly.

47. PISTONS AND PISTON RINGS.

a. It is recommended that piston rings be replaced at each overhaul period. Two important clearances must be obtained when installing new piston rings, the side clearance between the rings and ring grooves and the ring gap between the ends of the rings when in place in the cylinders in which they will operate.

b. The uniflow type piston used in R-1820 engines is provided with five piston ring grooves above the piston pin hole and one groove at the bottom of the piston skirt. These grooves are numbered from 1 to 6, starting with the groove nearest the head end of the piston as No. 1. The sides of the three top ring grooves are provided with a 15 deg taper, while the three bottom ring grooves have straight sides. The piston rings used in the three upper ring grooves have tapered sides which fit the tapered ring grooves in the piston and are also slightly tapered on the outside diameter. The three lower ring grooves are provided with three uniform width piston rings which are also provided with slight taper on their outside diameters. All piston rings are marked "TOP" on the side having the smaller outside diameter. The ring arrangement used on these pistons is as follows: Three rings with tapered sides are installed in piston ring grooves 1,

2 and 3, with the side marked "TOP" toward the head end of the piston. The fourth and fifth ring grooves are provided with uniform width piston rings which are also installed with the side marked "TOP" toward the head end of the piston. The bottom ring groove is provided with a uniform width compression ring which is installed in the inverted position in relation to the other rings, with the side marked "TOP" toward the open end of the piston.

c. To check the side clearance of wedge type piston rings proceed as follows:

(1) Tools required are a surface plate square, or a V-block or an angle shaped tool such as is illustrated in Figure 219, also a feeler gage.

(2) Assemble the wedge rings in the proper grooves in the piston, and place the piston, bottom down on a bench or other solid surface.

(3) Place the tool vertically against the thrust face of the piston adjacent to the piston pin relief machined in the side of the piston in such a manner that the two parallel edges of the tool contact the full length of the piston skirt. Do not hold the tool over the piston pin relief. Strap the tool in this position using strong rubber bands or their equivalent to hold the tools firmly against the piston skirt. Turn all rings until the gap of each ring is located approximately over the piston pinhole or 45 degrees from the tool.

(4) With one hand, press lightly on one of the wedge type piston rings on the side opposite the tool until that ring contacts the two parallel edges of the tool. Do not press so hard that the tool is pushed away from the side of the piston. With the other hand, insert a feeler gage between the top of that piston ring and the top of the piston ring groove, holding the feeler next to the tool. The side clearance at this location is thus obtained. (This operation is illustrated in Figure 219.) Measure the side clearance of all the remaining wedge type piston rings in the piston by repeating this operation with the tool in this same location.

(5) Without changing the position of the rings measure the side clearances of all wedge type rings in the same manner as directed in paragraph *c.* (4) above with the tool in three other locations approximately 90 degrees apart around the piston.

(6) If the side clearance thus obtained for any wedge type piston ring, measured at the front or rear of the piston, is not within the limits specified in the applicable Table of Limits for wedge type rings (AN 02-35-1), replace that ring with a ring of sufficient dimension to provide the proper side clearance.

d. The side clearance of uniform width rings may be obtained by installing a ring in the ring groove of the piston on which it will operate. Insert a feeler gage between the ring and groove and measure the clearance at several points around the circumference of the piston. Refer to the Table of Limits in Section XII. Make certain that the groove is clean before checking this clearance, otherwise an accurate check of the clearance cannot be made. Oversize width piston rings are available which will permit obtaining the recommended side clearance. Do not grind or lap any piston ring to reduce its width.

e. If the side clearance, thus obtained for any piston ring is not within the limits specified in the Table of Limits in Section XII, replace that ring with an oversize ring which will give the proper side clearance.

f. After the proper size ring has been selected for each ring groove, check it for gap. Care must be taken that each ring is kept in its proper position in relation to its location in the piston in which it belongs.

g. Check each ring for gap in the cylinder in which it is to operate or in a standard size barrel or gage. This practice should be followed to avoid improper gapping through the use of an oversize cylinder when checking the gap on standard size rings.

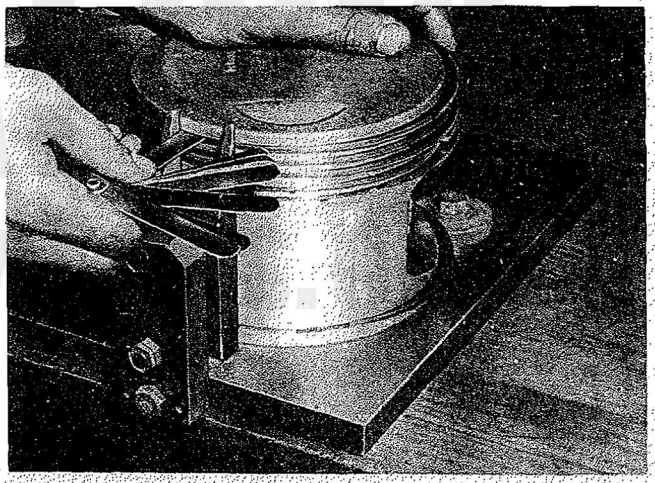

Figure 219—Measuring Side Clearances of Wedge Type Piston Ring

h. To check for gap, remove the rings from the piston and slide the piston in the cylinder barrel until the end of the piston skirt is 2 or 3 in. from the end of the cylinder skirt. Place a ring in the barrel against the piston skirt and pull the piston so that the ring is about 1 in. from the edge of the cylinder skirt. This places the ring where the gap between the ends can easily be

checked with a feeler gage and also insures the ring being located square with the cylinder bore. Refer to Figure 220. Consult the Table of Limits for the desired gap. If the gap is not sufficient remove the ring from the cylinder and file the ends of the ring. Use caution when filing to keep the ends of the rings square. After obtaining the desired gap break the sharp edges at the filed surfaces.

i. Fit all the rings for one piston in the manner described, then reinstall them in their proper places on the piston before fitting the rings in the next cylinder.

j. Stamp the identification number on a new piston 1-3/16 in. from the outside edge and midway between the two valve head recesses.

48. ROCKER ARMS.

a. Before assembling rocker arms, push rods and push rod housings refer to paragraph 1. of this section.

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b.

Deleted in revision
dated April 15, 1944

c. Screw the adjusting screws into the rocker arms until the shoulders on the screws contact the bottom face of the rocker arms. Place new lock washers on the clamp screws in the rocker arms. Do not tighten the clamp screws at this time.

49. IGNITION WIRING MANIFOLD ASSEMBLY.

a. Before reassembling the ignition harness install new ignition cables in the manifold. Cut the ignition cables to the lengths specified in the following table:

Right Hand Magneto (Block Numbers)	*Front Spark Plugs (Cylinder Numbers)*	*Order of Wiring Manifold*	*Wire Length (Inches)*
1	1	9	76
2	3	5	85
3	5	1	98
4	7	12	90
5	9	17	80
6	2	8	80
7	4	3	90
8	6	10	98
9	8	14	95

Left Hand Magneto (Block Numbers)	*Rear Spark Plugs (Cylinder Numbers)*	*Order of Wiring Manifold*	*Wire Length (Inches)*
1	1	18	85
2	3	6	96
3	5	2	111
4	7	13	103
5	9	16	94
6	2	7	94
7	4	4	103
8	6	11	111
9	8	15	96

b. After cutting new ignition wire to size for installation in the manifold, each wire should be tested for leaks or defective insulation. This test may be accomplished with any suitable high tension electrical equipment such as a portable booster magneto.

c. The use of powdered talc or powdered mica is recommended as an aid when feeding the wires through the manifold, the talc or mica acting as a lubricant will allow the wires to slide more easily over each other. Apply the talc or mica to each wire before entering it in the manifold as follows: Place some talc or mica in a receptacle and while holding a portion of the wire submerged with the fingers of one hand draw the complete length of the wire through the powder with the other hand. As each cable is treated with powdered material, feed it into the manifold in the numerical order shown on the wiring assembly diagram. Refer to Figure 221.

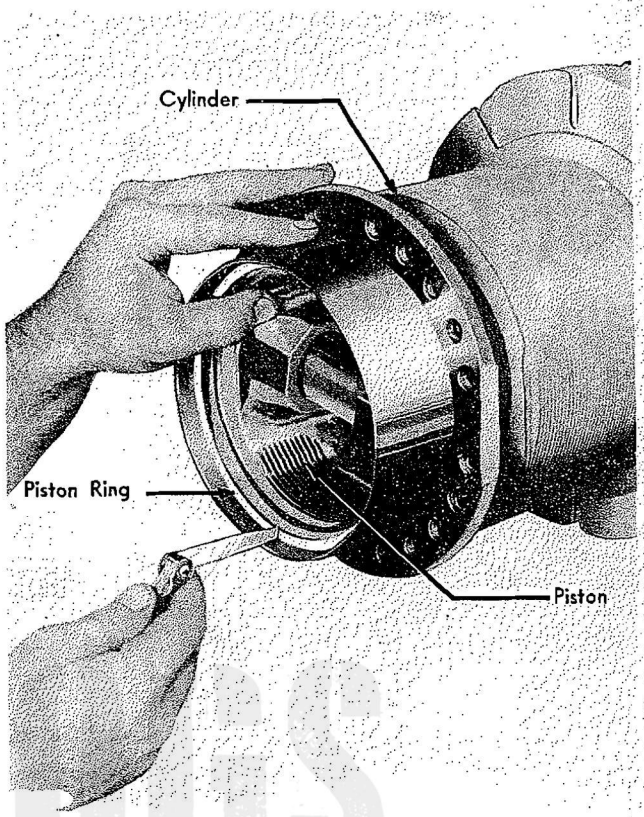

Figure 220—Measuring Piston Ring Gap

d. Each half of the manifold ring should be wired separately starting with the right half (facing the rear of the manifold).

e. For example the first wire to be installed is F 5 or that one leading from No. 3 block to the front plug of No. 5 cylinder. The second wire is R 5 or that one leading from block No. 3 to the rear plug of No. 5 cylinder. F 4 and R 4 wires follow next and this procedure should be continued according to Figure 221 until all wires are in place. Push the wires through the large opening in the manifold marked "R." As the installation of each wire is completed, install a

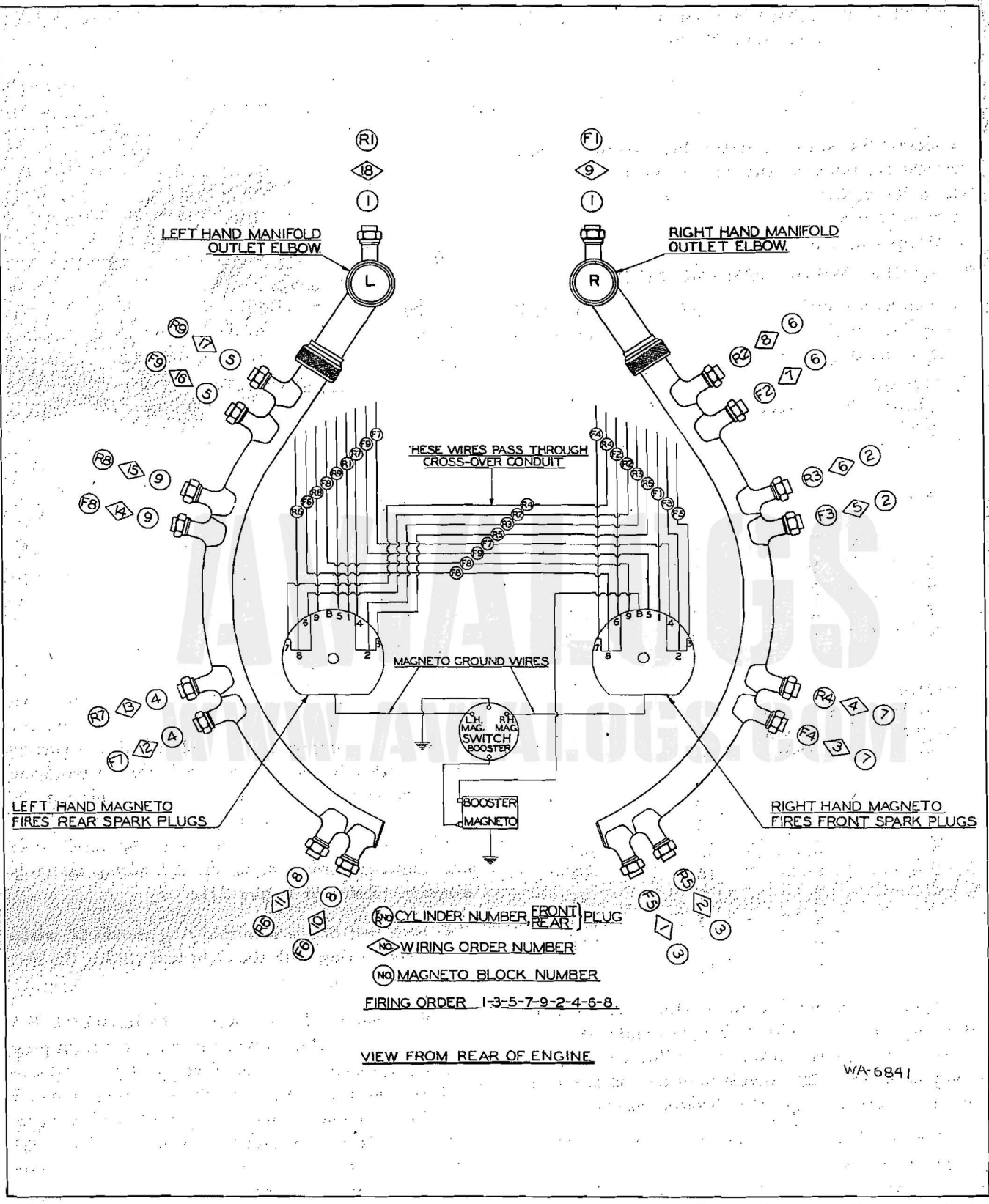

Figure 221—Ignition Wire Diagram

brass washer on the magneto end denoting the position of the wire in the distributor block.

f. Exercise extreme care while wiring the manifold to avoid abrasion or other damage to the ignition wires. A weak spot or break in the insulation will result in subsequent failure.

g. In the event new shielding braid is necessary, replace with a new braid and new couplings.

h. Screw the magneto outlet adapter front flange on the long conduit and push the wires with markers through the conduit. Attach the long conduit to the right half of the manifold ring. Determine which wires pass through the magneto outlet adapter rear elbow for attachment to the left hand magneto and which pass through the bottom of the outlet adapter for attachment to the right hand magneto. Refer to Figure 221. Insert the wires through their respective locations and attach the magneto outlet adapter front flange, adapter outlet, and rear elbow together, using the long through bolts.

i. Wire the left half of the manifold in the same manner, starting with ignition wire No. 10 and passing out through the outlet marked "L." Refer to Figure 221.

j. Install the cross-over tube, inserting the wires through the tube and out their respective outlets.

k. When all the wires are properly placed and protrude through the magneto adapter outlets, it will be necessary to trim the wires in accordance with the following table:

Left Hand Magneto Block Wire Number	**Trim to Length (Inches)*	*Right Hand Magneto Block Wire Number*
1	6	1
2	5	2
3	4-½	3
4	4	4
5	4	5
6	4	6
7	4-½	7
8	5	8
9	6	9

* This length to be measured from magneto adapter outlet lower parting surface to end of wire.

l. Place a new rubber washer over the spark plug end of each cable and slide it down into the nipple on the ignition manifold. Install the spark plug terminal conduit over the ignition cable and secure to the manifold by tightening the knurled coupling nut. Allow sufficient cable to protrude from the end of the conduit to install the spark plug terminal elbow and terminal sleeve. Install a rubber washer and the elbow on the ignition cable and secure the elbow to the conduit by tightening the knurled nut. It is recommended that Dow Corning Compound No. 4 be inserted in the elbow at this time to prevent condensation from forming thus causing subsequent failure of the cable insulation. To accomplish this, use an Alemite type pressure gun with a suitable adapter to fit the terminal nut. Insert the end of the ignition cable into the adapter and screw the spark plug terminal nut down tight on the adapter. Inject Dow Corning Compound No. 4 into the spark plug elbow by means of the pressure gun. Care must be taken to prevent the compound from forcing the ignition cable back into the spark plug elbow. After filling the spark plug elbow, remove the pressure gun and wipe off any excess compound on the ignition cable with a clean lintless cloth. Since the compound has an adhesive quality, care must be taken that coated surfaces and the compound are kept clean of foreign particles and dirt. Remove about 1/4 in. of the insulating material from the end of the spark plug cable and insert the end of the exposed wire through the brass washer in the insulating sleeve. The stripped end of the cable should protrude through the hole in the washer at the base of the contact spring about 1/8 of an inch. Fan the strands of cable around the washer and press the strands securely into position over the end of the contact washer nipple by means of a short copper tube (1/8 in. I.D.) Install a bakelite contact protector over each terminal.

m. Remove 1/2 in. of the insulation from the magneto end of each wire. Separate the strands of wire, space them evenly and fold back over the insulation. Install the thin brass washer over the end of the wire and secure it in place using the special pliers (Tool No. 803828). Refer to Figures 222 and 223.

n. Apply a thin coating of Dow Corning Compound No. 4 on the surface of each ignition cable for a distance equivalent to the depths of the respective terminal wells in the distributor blocks. Insert the ignition cables numerically in their respective positions in the distributor blocks. Insert and tighten the piercing screws which secure the wires in the blocks. Refer to Figure 224. Remove any excess compound with a clean lintless cloth. Install the magneto block covers,

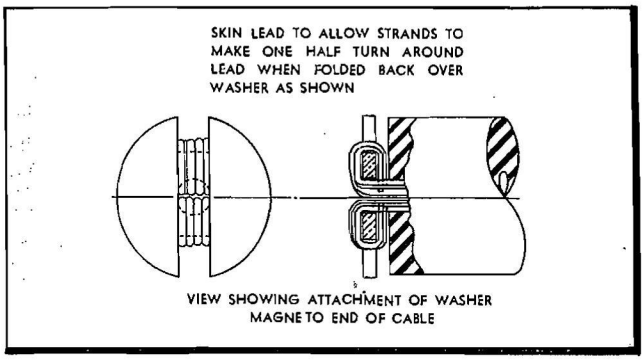

Figure 222—Method of Installing Washer on Ignition Cable

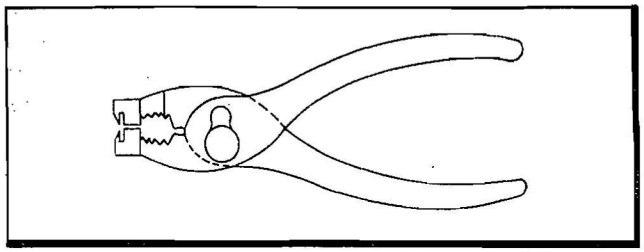

Figure 223—Special Pliers Used to Install Washer on Ignition Cable

and secure each with the two clamping cap screws and nuts, and two lower retaining cap screws. If the wires are too long, feed them back into the manifold as much as possible so that the extra length may be used for future repairs, if this should be necessary.

o. Install the coil cover on the magneto and secure it at the breaker end with the two screws. Secure the coil cover and radio shield to the front end plate with the six long screws. All the coil cover screws should carry lock washers.

p. Strip back the insulation from the ground wire for about 3/16 in. and twist the wire slightly. Install the insulating rubber washer and insert the wire through the brass contact button. Pull the insulating sleeve and rubber washer away from the contact and fan the wire out slightly. Solder the wire to the contact button and file the solder flush with the end of the contact.

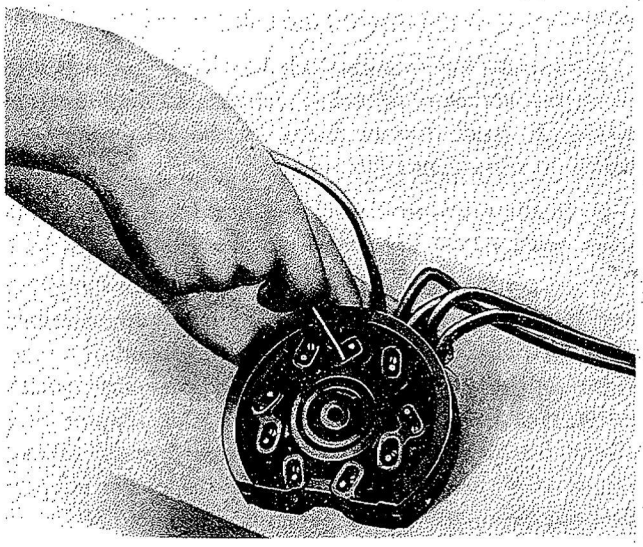

Figure 224—Attaching Ignition Wire in Distributor Block

q. Insert the round terminal into the sleeve in the magneto breaker housing and secure the assembly with the knurled nut. Lock the knurled nut with the spring wire lock ring.

r. Tighten the knurled coupling nuts securing the radio shielding at both ends of the "Y" terminal or install the cap if the terminal is not used.

s. After the ignition manifold assembly is complete, check each wire for proper location, leaks and faulty insulation with a portable magneto. Refer to Figure 224 for proper location of the wires. Install bakelite contact protectors on each spark plug elbow and secure by means of the spark plug attaching nut.

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SECTION IX
FINAL ASSEMBLY

1. GENERAL.

a. During the assembly of an engine there are certain operations which should be witnessed or inspected by the shop foreman or inspector. The inspector should initial or sign his name at each item after the operation has been witnessed or the inspection made on the inspection form.

b. Any steel component parts or assemblies included in final assembly of the engine, which have not yet been treated with a heavy coating of corrosion preventive mixture, will be so treated before final assembly. This mixture consists of one part engine corrosion preventive compound, Specification No. AN-VV-C-576, to three parts lubricating oil, grade 1120, Specification No. AN-VV-O-446.

2. SUPERCHARGER FRONT HOUSING.

a. With the disassembly and assembly stand engine mount plate turned to its lowest horizontal position in the stand, place the supercharger front housing on the plate with the open portion facing the plate and the top of the housing toward the cut-out portion of the plate. Secure the housing to the plate with the long bolts, inserted from the bottom of the plate, flat washers, and nuts.

3. CRANKCASE REAR MAIN SECTION.

a. If the crankcase rear main section was removed from the supercharger front housing, install it at this time. Secure the crankcase section to the supercharger front housing with the eighteen cap screws and spherical seat washers inserted from the rear of the supercharger front housing. Tighten the cap screws and lockwire in pairs.

NOTE

Make certain that the rubber oil seal is placed between these two sections at assembly.

4. CRANKSHAFT, MASTER ROD, AND ARTICULATED ROD ASSEMBLY.

a. Install a lifting eye in the crankshaft front extension, screwing it on the reduction driving gear retaining nut threads. Lower the crankshaft assembly carefully onto the rear main section, placing the master rod in the No. 1 cylinder pad location and the articulated rods in their respective locations. Refer to Figure 225. When the assembly is in its proper location, remove the lifting eye and install the crankshaft front end protector (Tool No. 800986).

b. Use extreme care when lowering the assembly not to damage the outer race of the rear main bearing. Refer to the Table of Limits in Section XII for proper fit of the bearing in the retainer.

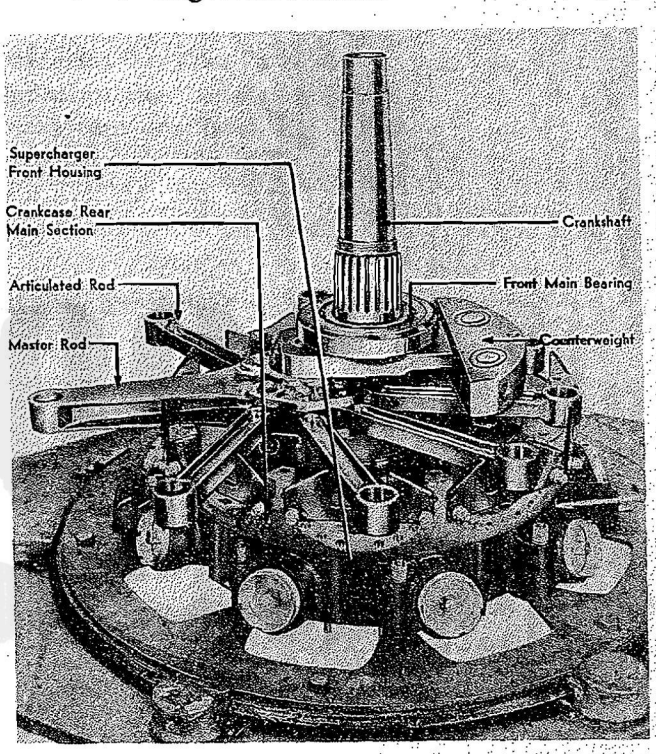

Figure 225—Crankshaft Assembled to Crankcase Rear Main Section

5. CRANKSHAFT FRONT MAIN BEARING INNER RACE.

a. Heat the inner race of the crankshaft front main bearing in an oil bath at 108° C (225° F) for ten minutes. Install the race on the crankshaft front extension tapping the race lightly with a fiber drift while cooling to insure a tight fit against the shoulder of the crankshaft.

6. CRANKCASE FRONT MAIN SECTION.

a. Place the crankcase front main section on two wooden blocks so that the section is supported at opposite points on the crankcase front section parting surface. Insure that the cam drive gears are free of

the blocks. Note that the bearing outer race is marked "PROPELLER END" for proper installation. Assemble the outer race and rollers in the bearing retainer and, if necessary, tap them into position with a fiber drift. However, if the outer race is loose in the retainer assemble the roller and outer race on the front race which is installed on the crankshaft.

b. Turn the crankcase front main section over so that it rests on the crankcase rear main section parting surface. Install the reduction driving gear spacer and ring assembly. Tap the spacer in place against the front main bearing outer race.

c. Coat the mating surfaces of both the crankcase front and rear main sections with a non-hardening gasket sealing compound and install the nine short rubber seals at these mating surfaces on the crankcase rear main section. Make certain that the seals are in their proper position before continuing the assembly. Refer to Figure 226.

d. Install the new oil seal rings over the oil passage dowels. Install the crankcase front main section and cam drive gear assembly over the crankshaft front extension, locating the proper cylinder pads and insuring that the oil dowels are lined up. Make certain that the rings are in their proper position. Insert the crankcase main section internal attaching bolts and nuts. Using a torque wrench, tighten the nuts to the required torque value and insert cotter pins. Refer to the Table of Limits in Section XII. Refer to Figure 227. After tightening the main crankcase attaching bolts and nuts, cut off the seals flush with the side of the crankcase.

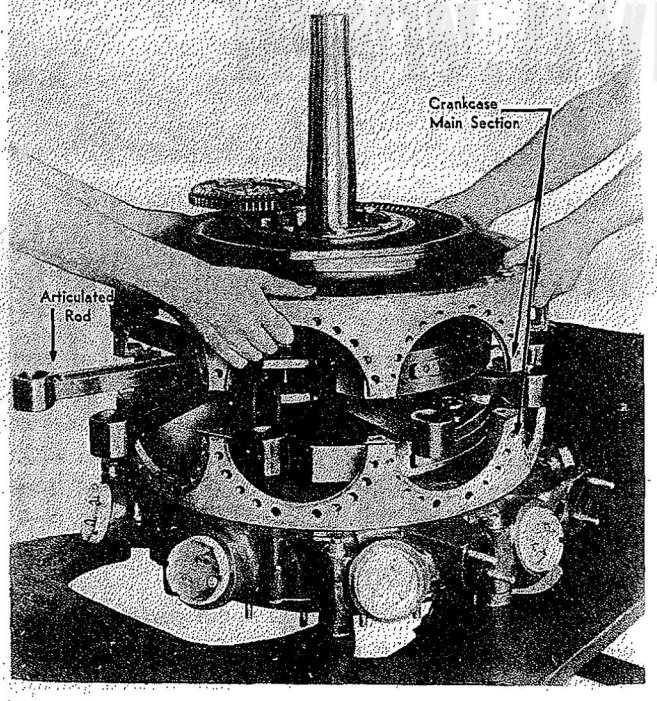

Figure 226—Installing Crankcase Internal Attaching Nuts

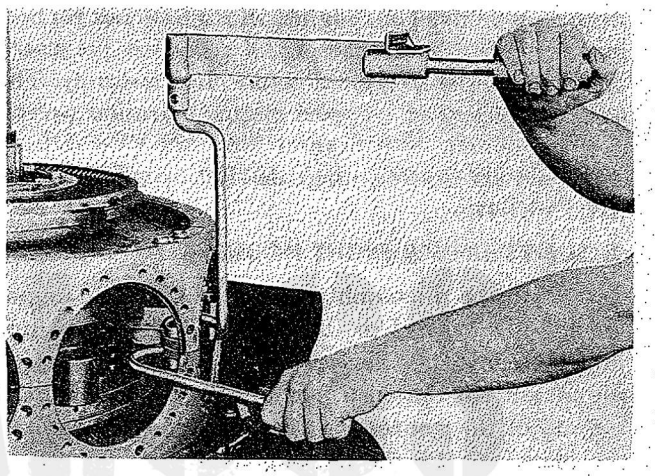

Figure 227—Tightening Crankcase Internal Attaching Nuts

7. REDUCTION DRIVING GEAR OR COUPLING.

a. Turn the intermediate cam drive gear until the timing marks on the pinion gear line up with similar marks on the cam. In this position the timing marks on the teeth of the intermediate cam drive gear nearest the crankshaft should be directly in line with the center line of the crankshaft. Refer to Figure 228.

b. Turn the crankshaft until the reduction driving gear or coupling locating pin is 90 deg counterclockwise from the timing marks on the intermediate cam drive gear.

c. Heat the reduction driving gear or coupling in an oil bath at 190° C (375° F) to 204° C (400° F) for 30 minutes. Coat the crankshaft reduction driving gear or coupling splines with Lubriplate 130-A, or its equivalent. Install the reduction driving gear or coupling on the crankshaft splines, locating the blind spline in the reduction driving gear or coupling over the pin in the crankshaft front extension splines, which is located 90 deg counterclockwise from the timing mark on the intermediate cam drive gear.

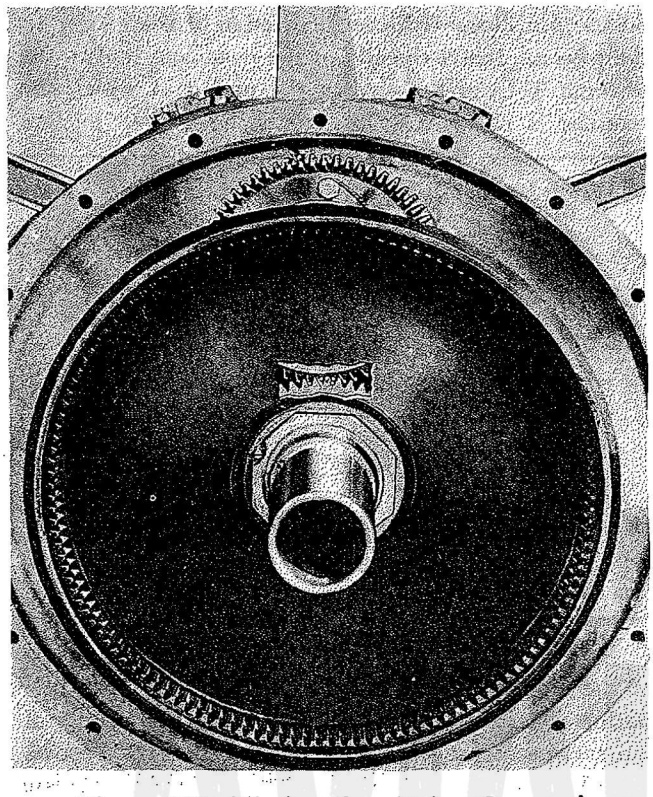

Figure 228—Timing Cam Drive Gear and Reduction Drive Gear

CAUTION

In the event the reduction driving gear or coupling seizes on the shaft during installation, do not attempt to remove it while hot. Allow the parts to cool to room temperature and remove the gear using the puller (Tool No. 84857) and the following adapter: Tool No. 84858. This procedure will prevent scoring of the shaft and reduction driving gear.

d. Install the special nitrided steel ring over the crankshaft front extension and install the reduction driving gear or coupling retaining nut. To prevent the crankshaft from turning, install a fiber drift in the piston pin eye of the master rod and turn the crankshaft so that the drift rests against the cylinder pad. Tighten the retaining nut, striking the shank of the wrench (Tool No. 82670) with a lead hammer.

e. After the reduction driving gear or coupling has cooled, remove the retaining nut and the nitrided steel ring. Install the crankshaft lifting eye (Tool No. 82151) and check the end play of the crankshaft. Place the base of the indicator dial on the crankcase front main section and the indicator on the reduction driving gear or coupling. Raise and lower the crankshaft by means of a chain hoist and determine the existing end clearance. Refer to the Table of Limits in Section XII for proper end clearance. Remove the crankshaft lifting eye and reinstall the retaining nut. Tighten it as previously described and lock it securely with the lock screw.

8. CRANKCASE FRONT SECTION.

a. Before installing the crankcase front section, install the large oil seal packing ring in its groove in the crankcase front section.

b. Install new oil seals over the oil passage dowels.

c. Coat the crankshaft front extension with corrosion preventive mixture. Attach a lifting eye and chain hoist to the propeller shaft and lower the crankcase front section and propeller shaft assembly over the crankshaft front extension. Use extreme care not to damage the propeller shaft bushings. Insure that the oil passage dowels line up with the mating holes in the crankcase front section. It is desirable to remove the cover plate from the governor mount pad and turn the governor drive gear to insure proper meshing of the gears. Secure the crankcase front section to the crankcase front main section with plain washers and cap screws. Insure that the four ignition harness manifold mounting brackets are located in their proper position, on the raised cap screw bosses. These brackets should be secured with the long crankcase front section attaching cap screws. Tighten all the cap screws and lockwire in pairs.

d. The above procedure applies to engines of both .5625 (16:9), .666 (3:2) ratio reduction, and direct drive engines, but the .666 (3:2) reduction requires, in addition, that the propeller shaft must be timed in relation to the crankshaft. Because of the pin in the coupling on the direct drive engines, no mistake can be made.

e. Turn the crankshaft until the master rod is at the top center position of its stroke as set by the top center indicator (Tool No. 80932). Do not move the crankshaft from this position.

f. Place the pointer (Tool No. 800157) on the propeller shaft so that the wide spline space in the tool encloses splines No. 1 and No. 16.

g. Turn the propeller shaft until the pointer (Tool No. 800157) indexes with the center of the timing mark on the front section flange.

h. Move the front section into place, engaging the pinions with the reduction driving gear. If engagement is not possible with the propeller shaft in this

position, turn the propeller shaft very slightly to obtain tooth meshing in the nearest tooth location.

i. Check the top dead center indicator (Tool No. 80932) to make certain that the crankshaft has not been turned. Check the pointer (Tool No. 800157) to make certain that it indexes within the limits of the timing mark on the front section flange. This mark is made wide enough to accommodate the permissible error.

j. Remove the pointer from the propeller shaft and complete the installation of the front section as described above. Remove the lifting eye.

9. BREATHER TUBE ASSEMBLY.

a. Place the breather tube rear gasket inside the propeller shaft over the front bushing. Lubricate the bearing surfaces of the breather tube with clean engine oil, and install the breather tube. See to it that the front flange of the breather tube seats squarely on the rear gasket and propeller shaft front bushing. Place the front gasket over the breather tube flange, and install the adapter or plug, whichever is used. Install the breather tube retaining nut inside the propeller shaft, and tighten with the special plug wrench. Place the crankshaft breather screen over the retaining nut, and secure it with plain washers, screws, and lock wire. Better alignment of the screw holes in the screen and in the retainer nut may be obtained by inverting the screen. Install the propeller shaft protecting cap.

10. VALVE TAPPET GUIDES.

a. Install new gaskets over each valve tappet guide mount pad attaching studs. Install the valve tappet guide assemblies and secure with plain washers, nuts, and palnuts. Note that each tappet guide is etched to identify its proper position.

11. CYLINDERS AND PISTONS.

a. Install the engine turning hub (Tool No. 82284) with handles (Tool No. 80292) on the propeller shaft. Rotate the propeller shaft until the master rod in No. 1 cylinder is at the top of its stroke.

b. Two types of piston pin and piston pin retainer combinations are used in the subject engines. When coil spring piston pin retainers are used, install the retainers in the rear side of each piston before assembling the pistons on the rods.

c. To install a piston pin retainer in the groove on the rear side of the piston, place the retainer spring on the installing tool (Tool No. 84861) with the spring joint approximately 90 deg either side of the cut-out in the tool. Refer to Figure 229. Install a piston pin in the piston with the large diameter of the chamfer on the pin flush with the inner edge of the groove in the piston. Insert the end of the installing tool in the piston pin from the side of the piston in which the retainer is to be installed, with the cut-out surface

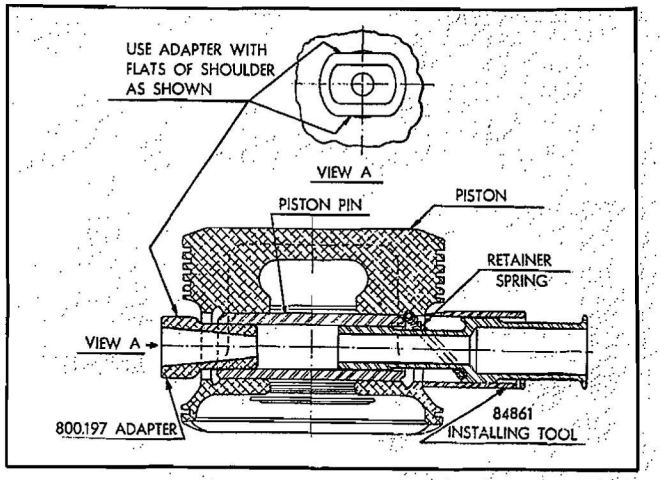

Figure 229—Installing Rear Piston Pin Retainer

of the tool at the top of the piston pin hole. While performing this operation locate the top section of the retainer spring in the top section of the groove. Install the adapter (Tool No. 800197) in the opposite end of the piston pin and, while holding the pin in position with one hand, apply pressure on the installing tool with the other and force the retainer into its seat in the retainer groove. Refer to Figure 230. Remove the installing tools.

d. Ensure that the retainers are correctly seated in the piston grooves, and that the spring joint is located approximately 90 deg from the vertical.

e. Lubricate the master rod piston pin bushing, the piston pin bores and the piston pin. Start the pin in the front of the piston, and locate the piston over the master connecting rod piston pin bushing. When the coil spring piston pin retainers are used, push the piston pin through the piston pin bushing and rear pin bore of the piston, until it bottoms on the rear retainer previously installed. When the aluminum plug type retainers are used, install the piston pin, and locate a retainer plug in each end. Support the retainer plugs until the ring clamp is installed over the upper piston rings and the plugs.

f. When the coil spring type piston pin retainer is used, install the front piston pin retainer in the same manner as described for installation of the rear retainer except that the adapter is not required since the rear retainer prevents the pin from slipping through the piston. Refer to Figure 231.

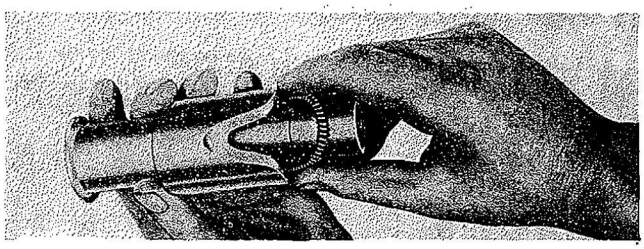

Figure 230—Installing Piston Pin Retainer in Installing Tool

g. Lubricate the lower 3 or 4 in. of the barrel of No. 1 cylinder with castor oil, AN-JJJ-O-316, and install a new rubber oil seal ring below the hold-down flange. Check that all piston rings are properly installed and set the gaps so that they are equally spaced (staggered) around the piston. When coil spring retainers are used, ensure that both retainers are correctly installed and seated. Lightly coat the side walls of the piston assembly, particularly the rings and ring lands, with castor oil, AN-JJJ-O-316.

h. Remove the connecting rod protector from the crankcase cylinder mounting pad. Make sure that the surfaces of the cylinder flange and crankcase mounting flange are clean and free from enamel. Compress the upper five rings with the clamp (Tool No. 80440) and slide the cylinder over these rings. When aluminum plug piston pin retainers are used, locate the ring clamp so that it compresses the five upper rings and supports the retainer plugs at the same time. Install the cylinder over the upper rings and piston pin retainers. Install the clamp over the bottom ring, and slide the cylinder over the ring and onto the crankcase mounting pad. Move the clamp to compress the bottom piston ring and slide the cylinder over the entire piston onto the crankcase mounting pad. Refer to Figure 232.

i. The cylinders are secured to the crankcase by means of spherical seat washers and cap screws. When installing these caps screws, carefully apply a very small amount of Glyptal, or its equivalent, to the cap screw threads to prevent oil leakage at these points. When a cylinder has been installed, locate it on the cylinder mounting pad immediately by tightening the two special locating cap screws (Tool No. 84501). Refer to Figure 233.

j. Install these two cap screws in two cylinder holes on opposite sides of the cylinder. Tighten these cap screws evenly and to the proper torque value, using wrench (Tool No. 82750) and torque indicating han-

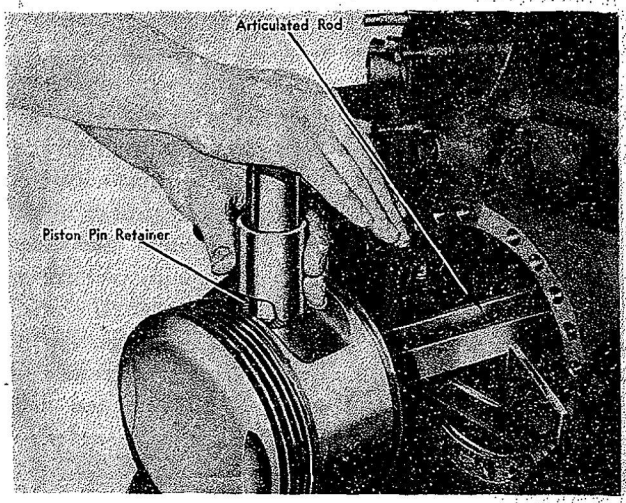

Figure 231—Installing Front Piston Pin Retainer

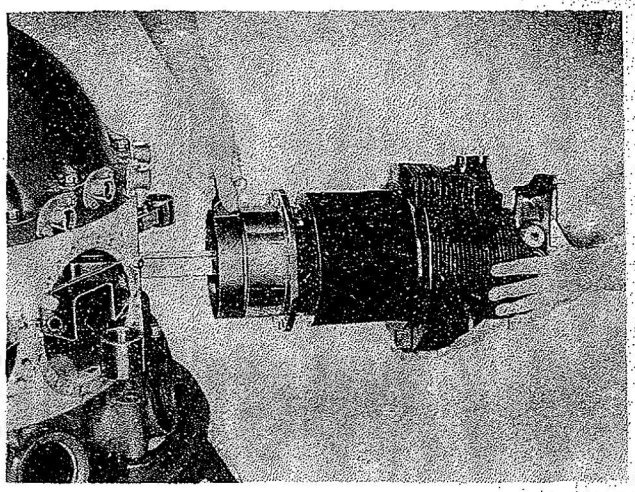

Figure 232—Installing Cylinder on Crankcase

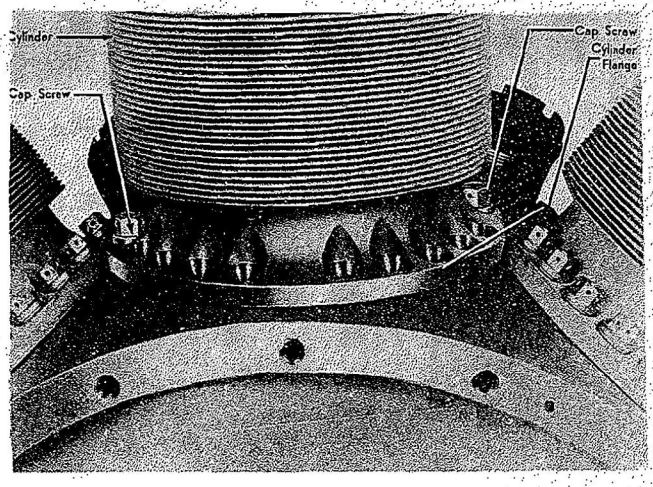

Figure 233—Locating Cylinder

dle (Tool No. 84922). Refer to the Table of Limits in Section XII.

k. Install a spherical seat washer on each cap screw and install the cap screw immediately after applying Glyptal, or its equivalent, to the threads. Install all the cap screws and tighten to the proper torque with the above-mentioned wrench and handle. Refer to Table of Limits for the proper torque. Tighten two cap screws approximately 90 deg from the locating cap screws first and then those approximately 45 deg from the first, repeating this procedure until all the cap screws have been tightened. Remove the two locating cap screws and replace with the standard spherical washers and cap screws and tighten to the specified torque value. Refer to Figure 234.

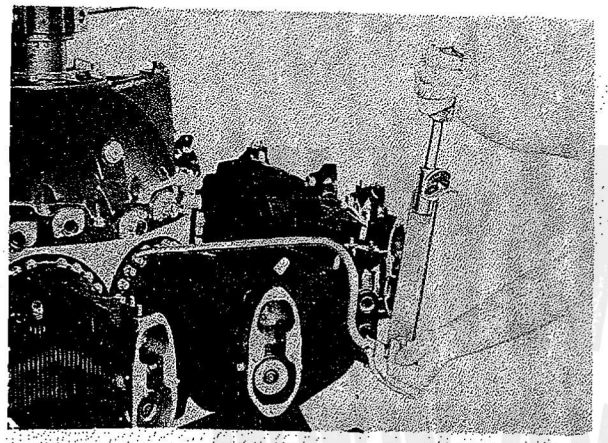

Figure 234—Installing Cylinder Hold-Down Cap Screw

l. Install cylinders 2 and 9 in the same manner. Turn the crankshaft until No. 4 cylinder is at top dead center and install cylinders 3, 4, and 5. Follow the same procedure as above for locating and tightening. Turn the crankshaft until No. 7 cylinder is at top center and install cylinders 6, 7, and 8.

m. Lockwire the cap screws in groups of five. Twist the wire between each nut and twist the ends together securely. Cylinder hold down cap screw locking plate P/N 138571 may be used in lieu of safety wire. Care must be exercised to secure the locking plate with a 1/16" x 3/4" cotter pin in the center cap screw of each locking plate.

12. VALVE TAPPET BALL SOCKETS.

a. Insert each valve tappet spring and valve tappet ball socket into its respective hollow tappet, insuring that all news parts are thoroughly coated with engine oil before assembly.

13. PUSH ROD HOUSINGS.

a. Install the long preformed hose connections on the No. 1 cylinder intake and exhaust valve tappet guides. These horses are marked to ensure that they will be installed correctly, with the bend turned in the correct direction.

(1) Install the hose connection on the intake valve tappet guide so that the two colored stripes parallel to the axis of the hose are turned 45° counter clockwise from the fore and aft center line of the tappet guide, as viewed from the propeller end of the engine. Install the hose connection with the colored end extending away from the front crankcase housing.

(2) Install the hose connection on the exhaust valve tappet guide so that the colored stripes are turned 45° clockwise from the fore and aft center line of the tappet guide as viewed from the propeller end of the engine. The colored end of the exhaust hose connection will also extend away from the crankcase.

b. Install the intake and exhaust valve push rod housings in the hose connections. Push rod housings of increased length should be used. These housings may be identified by the single bead at the crankcase end of the housing. Install the housings with the end having the adjacent bead toward the cylinder head.

c. Install the push rod housing hose connections on the push rod housings. Three screw type clamps will be installed on each push rod housing used on Army engines. Navy personnel will install four wire type clamps on each push rod housing, when clamps of the improved type are available. These clamps may be readily identified by the mark "C20" stamped in the wire. When the improved type of clamp is not available, five wire type clamps must be installed on each housing.

d. Install the short hose connections on the intake and exhaust valve push rod housings. Align the housings with the metal connectors in the rocker arm housings, and seat the hose connections against the rocker arm housings at the cylinder end and against the shoulder of the tappet guide at the crankcase end. Use the hose connection installing tool (Tool No. 83182) for this purpose.

e. When screw type hose clamps are used, locate one clamp on the hose connection over the beading at the rocker box end of the push rod housing, with the clamping screw aligned with the rocker box cowl attaching studs. Locate a clamp at each end of the inner hose connection, with the clamp screws at an angle of 45° from the rocker box cowl attaching studs. Tighten the clamp screws, using the special socket wrench (Tool No. 801122).

f. When wire type hose clamps are used, expand the clamps with the special hose clamp installing pliers (Tool No. 800867) and slide them into position at each end of the rocker arm housing push rod hose connection. Install one hose clamp at each end of the valve tappet guide push rod hose connection. When five of the earlier type of wire hose clamps are used, install the fifth clamp adjacent to the clamp at the outer end of the valve tappet guide push rod hose connection, with the joint of the clamp located 90° from the joint of the clamp previously installed.

14. PUSH RODS AND ROCKER ARMS.

a. The number of times it will be necessary to turn the crankshaft when installing push rods and rocker arms can be reduced to two complete revolutions if the rocker arms are installed in accordance with the engine firing order.

b. Screw the valve clearance adjusting screw into each rocker arm until the flange in the screw bottoms in the rocker arm.

c. Oil the push rod ball ends with clean engine lubricating oil and insert in the push rod housing through the rocker box. Lubricate rocker arms and bolts with clean engine oil. Install the rocker arm and insert the rocker bolt through its hub. Make sure that the spherical seat washers are installed at each end of the through bolt. The bolt should be installed with its head facing the centerline of the cylinder head.

d. Before tightening the castellated nut on the rocker bolt, check the end clearance between the bearing inner race and the rocker box. If it is over the limit specified in the Table of Limits, Section XII, remove the bolt and install a shim to take up the excess. It is important that the correct clearance be obtained at this location to prevent damaging the rocker box due to excessive clamping. Refer to Figure 235.

e. Tighten the rocker bolt nut to the torque value as specified in the Table of Limits, Section XII, using the torque wrench handle (Tool No. 84922) and a socket. Refer to Figure 236. If it is necessary to exceed the recommended torque value to line up the cotter pin hole, select another washer and nut. Insert

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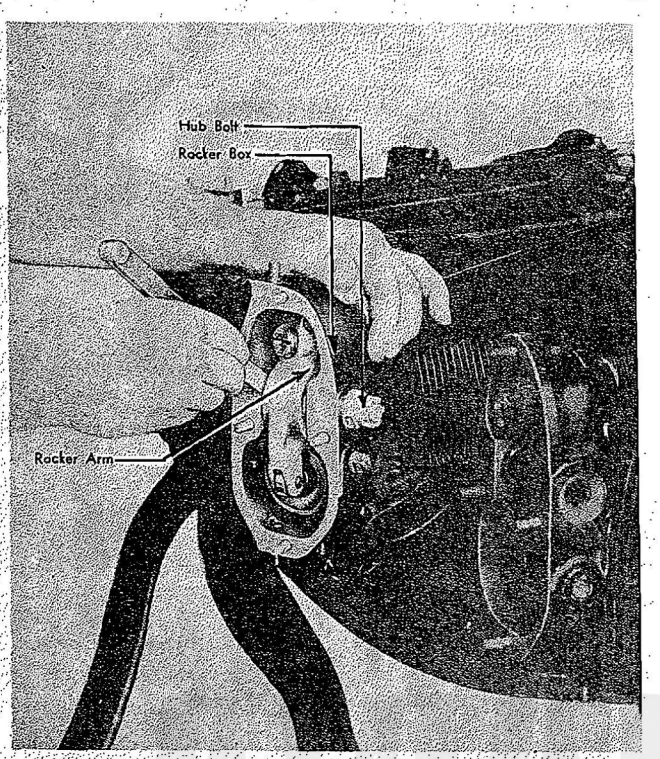

Figure 235—Checking End Clearance Between Rocker Arm Bearing Inner Race and the Rocker Box

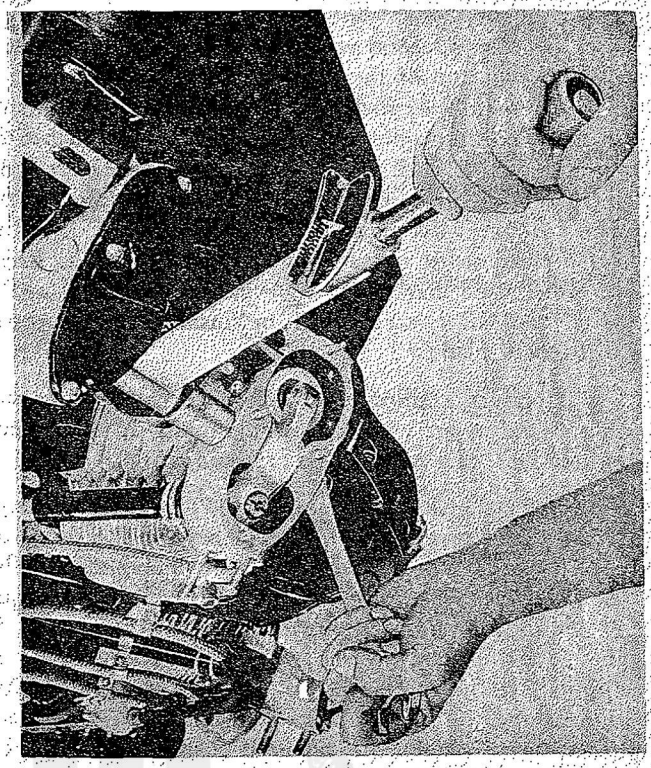

Figure 236—Tightening Rocker Hub Bolt Nut

a cotter pin which fits the hole properly and secure it by bending one end against a flat on the nut and the other end over the end of the bolt.

f. When installing rocker arms be extremely careful not to install the intake rocker arm in the exhaust rocker box or vice versa.

15. ADJUSTMENT OF VALVE CLEARANCES.

a. To adjust the clearance between the valve stem and rocker arm roller, turn the crankshaft until the piston in No. 1 cylinder is on top center on the compression stroke. In this position the valve tappet rollers are at their lowest point of travel on the cam ring between the cam lobes, which places both valves in the fully closed position. To check that No. 1 cylinder is on its firing stroke, test the two adjacent valves, No. 2 exhaust and No. 9 intake. When the intake valve to the left is approximately 1/2 open and the exhaust valve on the right is approximately 1/2 closed, viewed from the rear, the piston in the cylinder being checked is on top dead center on the firing stroke, with both valves closed. Refer to Figure 237.

b. Adjust valve clearance of each cylinder to 0.017" ± 0.003" starting with number 1 cylinder and continuing in normal firing order (1-3-5-7-9-2-4-6-8) insuring that the piston is at top dead center on compression stroke.

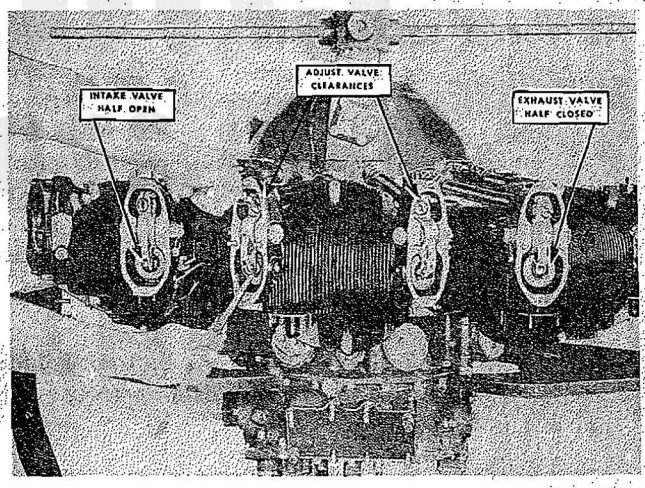

Figure 237—Adjusting Valve Clearance

On initial adjustment, all valves should be adjusted to the specified clearance without regard to the oil holes in the adjusting screws. Tighten lockscrews sufficiently so that adjusting screws will not turn when crankshaft is rotated.

NOTE

When checking the valve clearance the feeler gage will be moved in line with the roller pin and sufficient pressure applied on the push rod end of the rocker arm to over-ride the spring tension in valve tappet.

c. Conduct a second valve check. If the zero reference mark on the top of the adjusting screw aligns with, or is closer than 3/32 inch to the nearest edge of the slot in the rocker arm, the adjusting screw will be turned in either direction until the referenced mark is at least 3/32 inch from the nearest edge of the rocker arm slot. In no case will the valve clearance limits be exceeded. If the valve clearance is not within the specified limits when the referenced mark (0), is properly positioned, a different adjusting screw will be installed and proper adjustment made.

d. Conduct a third valve clearance check to insure that all valves are within allowable limits. If adjustment is necessary, this step will be repeated.

e. After the third and final check, tighten the lockscrew 135 degrees to 150 degrees beyond the point of noticeable drag or torque to 125-150 inch-pounds. The lockscrew must be tightened sufficiently so that a torque of 350 inch-pounds will not turn the adjusting screw. If the adjusting screw turns when the above torque is applied, readjust clearance on the affected valve. Retighten the lockscrews, but do not tighten more than necessary to obtain the required torque value on the adjusting screw.

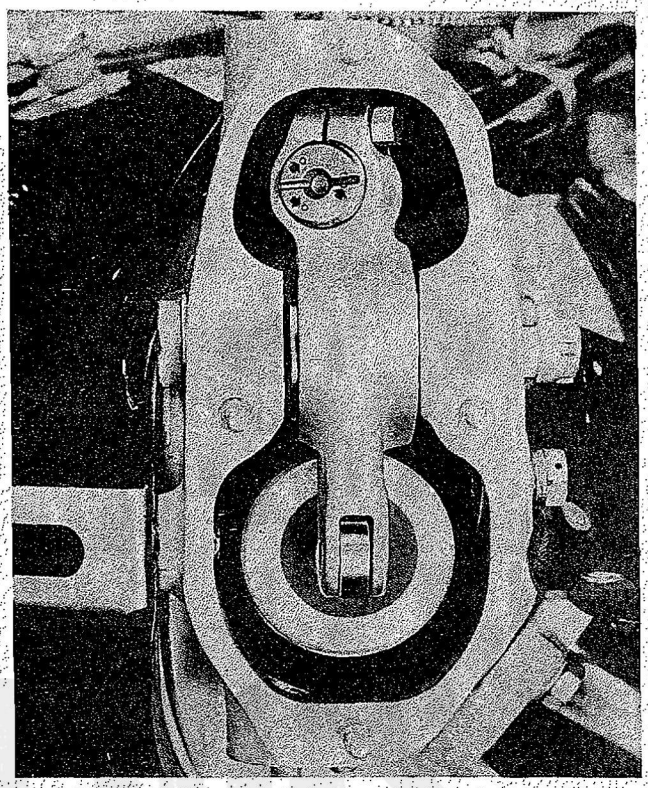

Figure 238—Location of Indexing Marks on Adjusting Screw

16. ROCKER BOX COVERS.

a. After the valve clearances have been properly adjusted, and with the crankshaft in a horizontal position, place gaskets over the studs on all rocker boxes except the master rod cylinder. Pour one-half pint of engine lubricating oil in the rocker boxes above the horizontal centerline. Install rocker box covers on those oiled rocker boxes, securing them with flat washers, nuts and palnuts. Do not install rocker box covers on the master rod cylinder at this time.

b. Rotate the engine to bring the bottom cylinders on top, pour lubricating oil in remaining rocker boxes and install covers.

Figure 239 deleted.

Figure 240 deleted.

17. SUPERCHARGER REAR HOUSING AND COVER.

a. Turn the engine on the assembly stand so that the propeller shaft points straight downward.

b. Place lifting eye (Tool No. 83863) on the starter mounting pad of the supercharger rear housing cover and secure it with the starter retaining nuts. Attach a chain hoist to the lifting eye and raise the rear section from its assembly stand until the impeller shaft front oil seal sleeve with rings is accessible.

c. Coat the impeller shaft front oil seal ring assembly with corrosion preventive mixture and stagger the ring gaps evenly.

d. Install a new gasket on the supercharger front housing parting surface. Pour clean engine lubricating oil into the crankshaft until it reaches a level covering approximately half of the starter coupling splines.

e. Thoroughly inspect the diffuser section and inside of the intake pipe bosses to insure no foreign material is present that will cause damage to the engine.

f. Insert the splined turning tool (Tool No. 82809) into one of the magneto drive shafts and carefully lower the supercharger rear housing into place, turning the gears with the turning tool to engage the splined end of the accessory drive shaft with the crank-

shaft coupling splines. Exercise care when lowering the housing to prevent damaging the impeller oil seal rings.

g. If the rear section sticks or any other difficulty is encountered while the supercharger rear housing is being installed, lift it from the engine and inspect the impeller shaft front oil seal rings for possible damage. Insure that rings are not twisted. An oil seal ring that is twisted will prove ineffectual as an oil seal and must be replaced with a new part.

h. Secure the supercharger rear housing to the front housing with plain washers, nuts, palnuts, and locate the supporting clamp and bracket assembly for the left main ignition manifold on the stud to the left of the impeller oil seal vent.

i. Remove the supercharger rear housing lifting eye and replace it with a cover plate. Secure the plate with plain washers, nuts, and palnuts.

18. IGNITION WIRING MANIFOLD.

a. Place the ignition harness in its approximate position on the engine. Place the two flexible conduits on either side of No. 1 cylinder and place the distributor blocks in their approximate positions at the rear supercharger housing. If the magnetos have been installed, insert the magneto distributor block in

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its recess in the magneto housing, using extreme care not to damage the contact buttons.

b. Place the magneto coil cover in its position on the magneto and secure both the magneto distributor block and the coil cover with the six slot-head cap screws, using a new lockwasher under the head of each cap screw.

c. Install the four clamps securing the two halves of the ignition harness to the four supports which are bolted to the crankcase front section.

d. Further assembly of the ignition harness is accomplished after installation of the cylinder air deflectors. After completion of the installation of the cylinder air deflectors, tighten the knurled nuts on each end of the magneto outlet elbow. Fasten the nuts which secure the braid to the manifold ring and attach these flexible radio shielded ignition leads to the push rod housings by means of the clamps. Secure the ignition leads for the front and rear spark plugs together by means of clamps to prevent vibration of the leads. Place the rear ignition leads in their respective locations in the channel sections of the cylinder head air deflectors.

e. Hold each terminal securing nut back and apply a thin coat of Dow Corning Compound No. 4 on the surface of each insulating sleeve. Also fill the contact spring secured to each insulating sleeve with the compound. Push the insulating sleeve into the spark plug well until the ridge at the end of the elbow rests in position on top of the spark plug barrel. Since the compound is an insulator, remove any excess which may be forced out at the top of the spark plug barrel with a clean lintless cloth. Secure the terminal elbow to the spark plug. Repeat this procedure for each spark plug terminal.

19. OIL SUMP.

a. Place the sump in its proper position and install the flat washers, nuts and palnuts, insuring that the oil passages are properly lined up. Refer to Figure 241.

b. Check to see that the magnetic sump plug and screened plug are installed and lockwired correctly.

20. EXTERNAL OIL SUCTION TUBES.

a. Install the front external oil scavenge tube securing it to the sump adapter with one short hose connection and two clamps. Attach the front scavenge tube to the intake push rod housing of cylinder No. 6 with a clamp, bolts, and nuts.

b. Insert the rear external oil scavenge tube through the drilled passage in the fire seal.

c. Using two clamps, and hose, attach the rear external oil scavenge tube to the front scavenge tube. Clamp the rear tube, using the clamp and extension, to the nearest stud securing the supercharger rear housing to the supercharger front housing. The extension is bolted to the clamp with a bolt, washer, and a nut. Assemble the rear external scavenge tube, securing it to the horizontal outlet of the pump with one short hose connection, and two clamps.

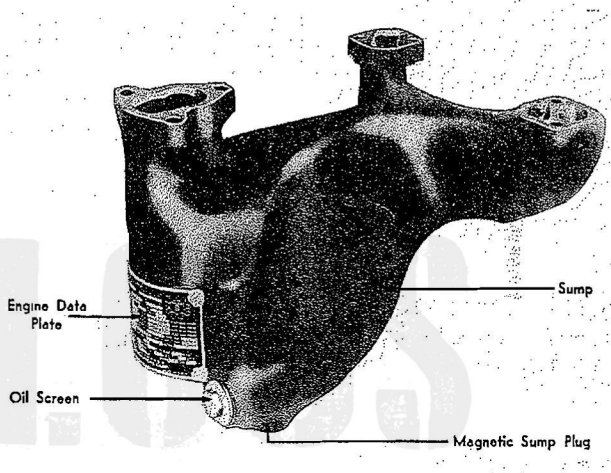

Figure 241—Oil Sump

21. EXTERNAL HYDRO OIL TUBES.

a. Install the elbow in the connection hole in the crankcase front section. Assemble the clamp and bracket on the front tube assembly. Insert the front end of the tube from the rear of the engine, under No. 7 intake pipe and under the intercylinder air deflector between cylinders No. 7 and 8. Screw the front connection nut onto the elbow installed in the crankcase front section. Do not tighten the nut at this time. Remove the nut and bolt at the adjustable portion of the rear scavenge tube clamp. Attach scavenge tube bracket extension, clamp, and front hydro tube right angle bracket together using a bolt and elastic stop nut. If no external scavenge tube is installed on the engine attach the hydro tube to the supercharger rear housing front flange using a one piece clamp and bracket.

b. Assemble the clamp and bracket on the rear tube assembly. Place a gasket over the two studs at the oil tube connection location on rear cover. Install the flange of the rear tube over the two studs and

start the two slotted hex nuts on the studs. Attach the rear tube to the front tube by means of the union nut and coupling provided. Install the rear tube bracket on the rear cover by removing one of the rear cover attaching nuts in a suitable location, placing the bracket over the stud and reinstalling the cover attaching nut. Adjust the position of the component parts of the assembly and securely tighten connections and bracket and clamp screws and nuts.

22. CYLINDER AIR DEFLECTORS.

a. Place the intercylinder air deflector clamp so that the edges of the channel-shaped clamp fit into the fifth and eleventh fin spaces, counting the space between the first and second fin at the crankcase end of the cylinder as No. 1. Place the air deflector in its approximate position between the cylinders and loosely install the bolt through the deflector, spacer and clamp. Install a new elastic stop nut but do not tighten it at this time. Line up the deflector so that the stud will protrude through the space between the two rocker box cover extensions. Install the grommet and retaining plate, secure with a new elastic stop nut. Tighten the air deflector clamp at the base of the air deflector.

b. To install the intercylinder air deflector at the sump location, place the deflector in its approximate position. Loosely install the two cap screws and washers securing the deflector to the two legs of the sump. Line up the stud with the space between the two rocker box cover extensions, install the rubber grommet and retaining plate and secure the assembly with a new elastic stop nut. Tighten the cap screws in the sump legs and lockwire securely.

c. Place the cylinder head air deflector in its approximate position and install one of the rocker box cap screws loosely. Install the second cap screw in the opposite rocker box and a third cap screw in the intake pipe mounting flange. Tighten the cap screws and make certain all are lockwired.

23. INTAKE PIPES.

a. Install a new packing ring in each intake port in the supercharger front housing, and loosely install the nine packing nuts.

b. Install a new packing ring under the intake pipe attaching flange at the cylinder end. Coat the crankcase end of the intake pipe with clean engine lubricating oil and insert into the supercharger front housing.

c. Place a new gasket under the intake pipe flange and secure the flange and gasket to the intake port with shakeproof washers and three cap screws. Tighten the cap screws evenly to the required torque value. Tighten the packing nut at the crankcase end of the intake pipe using the crowfoot type wrench (Tool No. 84258) and handle (Tool No. 81403).

24. PRIMING SYSTEM.

For engines equipped with five-point priming, attach the distributor to the clamp and place the clamp on the No. 1 cylinder intake pipe facing the rear, and at a location 8 inches from the center of the distributor to intake pipe packing nut. Do not tighten the clamp at this time. Place each priming tube in its approximate location and by placing No. 3 priming tube in one of the upper locations, slip the clamp over the intake pipe, install the nuts and bolts, but do not tighten. Screw on the union nuts at the intake ports and the distributor. Tighten each union nut at the intake port and distributor locations. Have the lower priming tube clamp set so as to have the tightening screw on the forward side. (See Figure 242.) Tighten all clamp nuts.

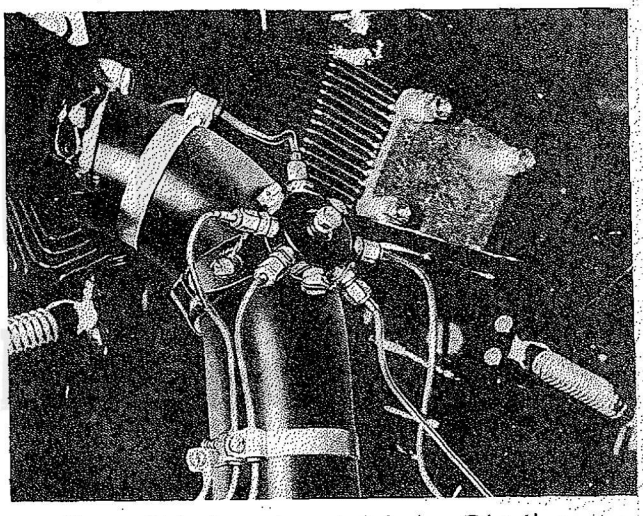

Figure 242—Location of Priming Distributor

25. ADJUSTMENT OF MAGNETO CONTACTS.

a. Before installing the magnetos these instructions should be followed: Be sure the magneto cam follower is not lodged between the fiber cam follower block and the cam. Should this occur and the points be adjusted, subsequent wear of the felt would change the magneto timing.

b. Turn the magneto drive shaft in the normal direction of rotation until the timing mark "A," refer to Figures 243 and 244, on the distributor rotor lines up with mark "B" on the magneto front end plate.

c. Place a 6 in. steel scale "K" against the face of the step cut in the cam "L." Turn the magneto drive shaft slightly until the straight edge coincides with the marks "M" and "N" cut in the rim of the breaker

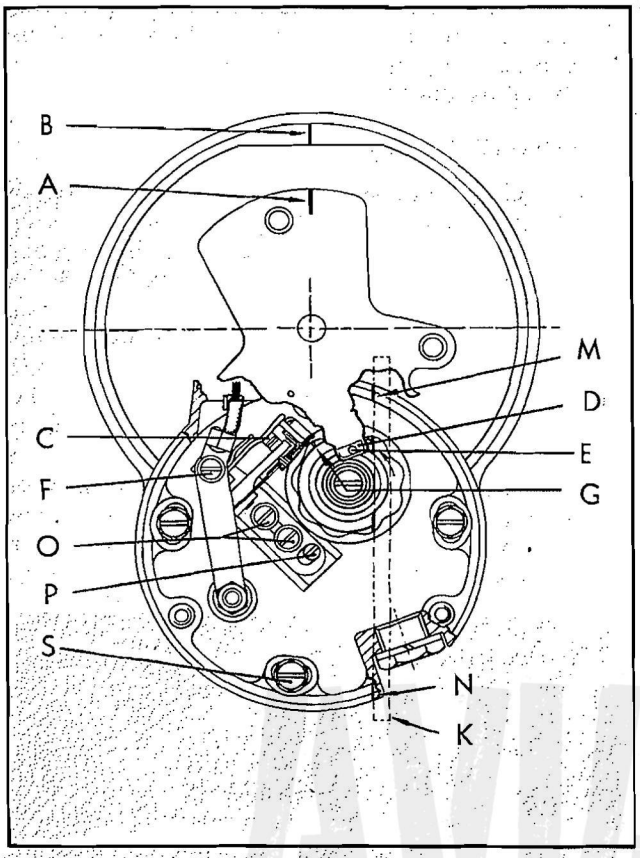

Figure 243—Sketch for Magneto Adjustments

housing. In this position, the high tension electrode "D" on the distributor finger will be opposite the distributor block electrode "E" for firing the No. 1 cylinder.

d. These pivotless breakers must always be adjusted so that the contacts open at the proper position of the cam and not for any fixed clearance between the contact points.

e. If inspection shows that the position of opening of the contacts requires adjustment, loosen the two screws "O," which fasten the breaker support to the breaker housing. Hold the cam in position to open the contacts as indicated by the straight edge and adjust by means of the eccentric screw "P" until the contacts are just opening. Secure them in this position by tightening the screws "O." This adjustment should be necessary only when installing new points or in unusual overhaul cases.

f. When the exact timing is to be made, all adjustments must be made at the drive end and not by altering the adjustment of the contact points.

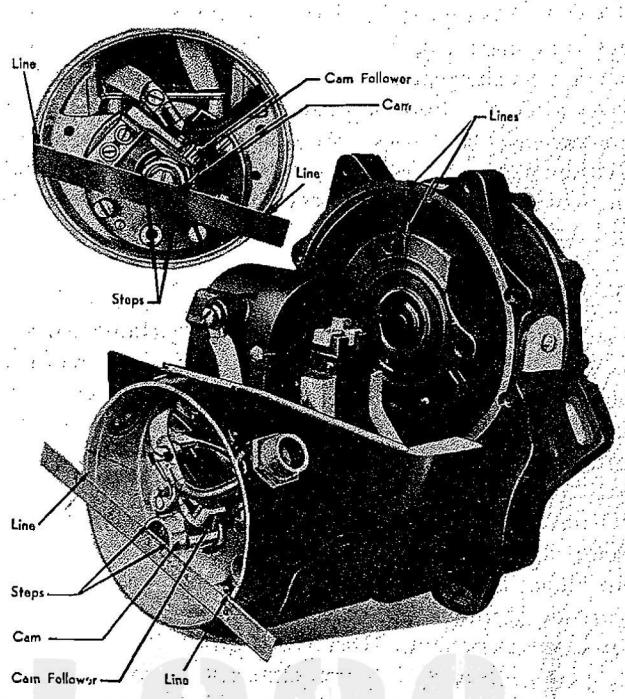

Figure 244—Adjusting Magneto Timing

26. MAGNETO INSTALLATION AND TIMING.

a. Install the timing disk (Tool No. 83517) and adapter (Tool No. 83533 or 800947) on the starter mount pad and rotate the crankshaft in the normal direction of rotation until No. 1 piston is at top center of the compression stroke. Refer to Figure 245. Check for top dead center using a top dead center indicator (Tool No. 80932) in No. 1 cylinder. Refer to use of top center indicator as described in Section IX, paragraph 27. Adjust the pointer on the timing disk installed on the starter pad to zero when the No. 1 piston is on top center on the compression stroke. Tighten the clamping screw to hold the pointer to its shaft in this position. Turn the crankshaft backward for approximately 1/4 of a revolution then forward to the spark timing value indicated on the engine data plate.

b. The position of opening breaker points will be checked by using the A-100 Abbott timing light (AF Stock No. 8042-273875) or equivalent. In the event a timing light is not available, a .0015-inch steel feeler gage will be used between the contact points "C" by lifting the felt covered cam follower "F" which causes the points to open. Do not open the points by lifting the breaker spring "G" as a permanent set may result from bending at the spring pivot.

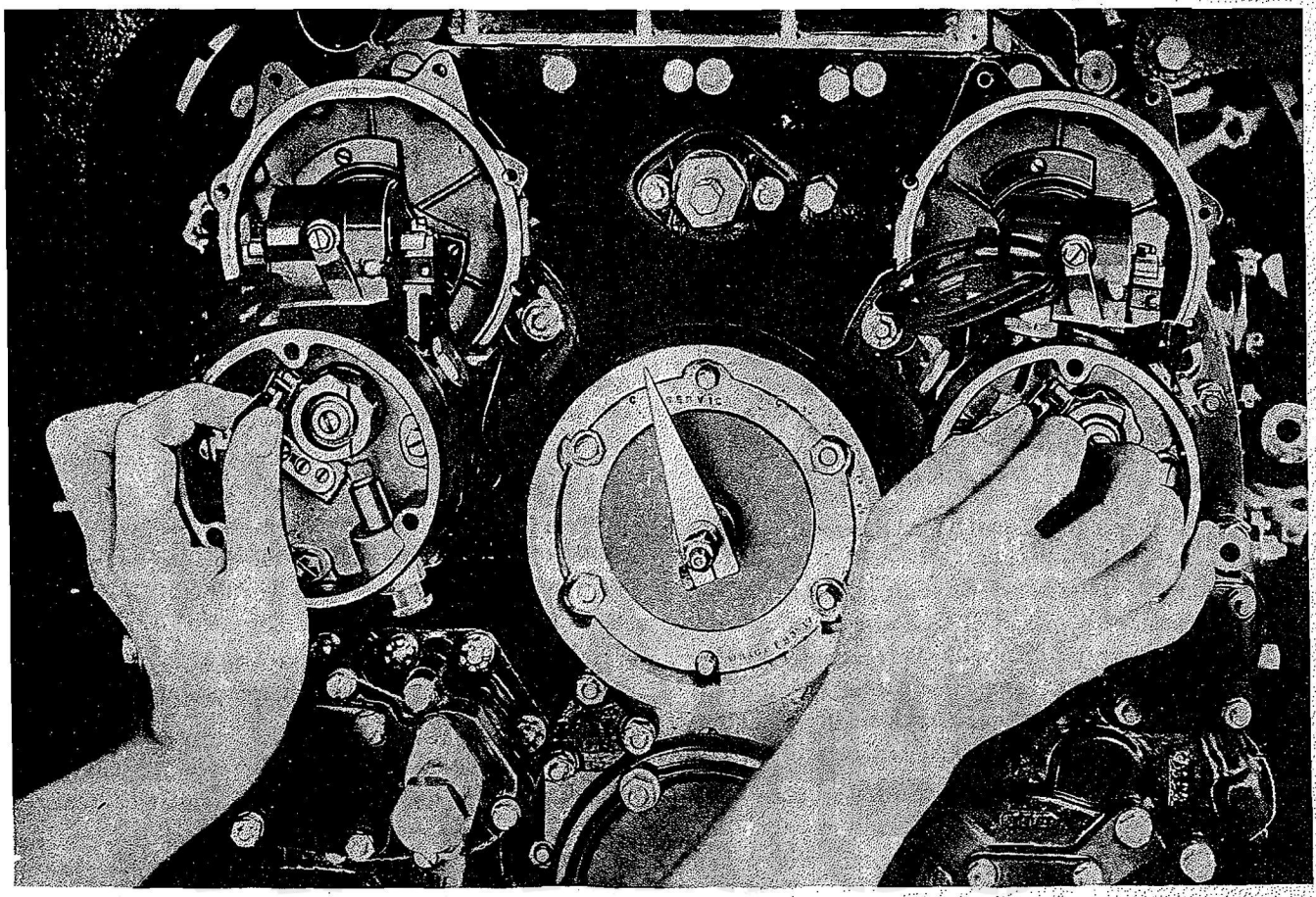

Figure 245—Magneto Timing

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c. A better method is to turn the magneto shaft in the direction of rotation until the breaker points are opened by the cam. Insert the feeler gage between the points and turn the magneto shaft in the direction opposite to normal rotation until the points close. Turn the shaft in the direction of normal rotation until the points begin to release the feeler gage indicating that the breaker points are just beginning to open.

d. Apply a heavy grade of corrosion preventive mixture to the splines of the magneto coupling gear. With the magneto timing marks aligned as described above, install the magneto on the engine. Refer to Figure 246. Move the magneto to its extreme positions allowed by the slots in the mounting flange, noting whether or not the breaker points open and close. If the breaker points open and close approximately half way between the two stops, assemble the flat washers and nuts on the magneto studs. Tighten the nuts sufficiently to hold the magneto firmly on the cover but not tight enough to prevent adjusting the position of the magneto. If the breaker points open at the middle of the travel of the magneto, further adjustment of the spark, either advance or retard, can be obtained to a certain degree without removing the magneto from the engine.

e. If the breaker points do not open while turning the magneto, remove the magneto from the engine and turn its shaft until the timing marks are lined up as described above and as shown in Figures 243 and 244. Fit the magneto again to the engine and test to see if the breaker points open. Continue this until proper opening is obtained.

f. Another method for resetting a magneto whose breaker points do not open during the angle allowed by the slots in the flange is as follows: Withdraw the magneto from the engine, install the magneto coupling wrench (Tool No. 82676) over the splined drive shaft coupling to keep the shaft stationary, and remove the cotter pin, castellated nut, and washer which retain the coupling on the shaft. The coupling which is fitted to the shaft by six slots on its inside diameter should be withdrawn, turned to the next slot engaging

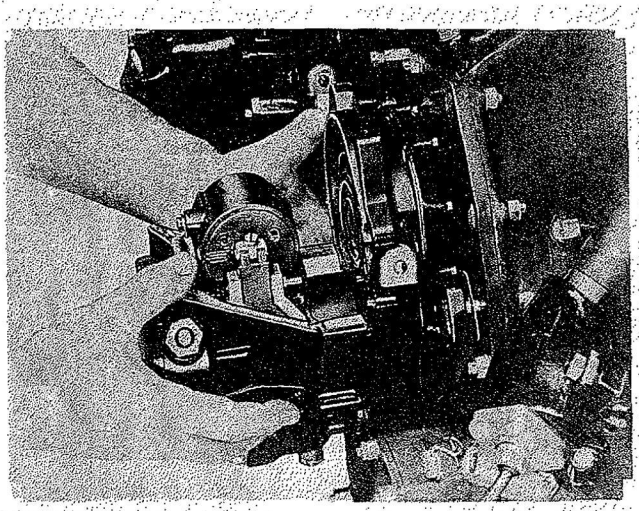

Figure 246—Installing Magneto

position, and reinstalled on the shaft. Install the retaining washer and nut and check the opening and closing of breaker points with the magneto on the engine. When the results are satisfactory, withdraw the magneto to install the cotter pin in the coupling retaining nut, and reinstall the magneto on the engine.

g. As the contacts begin to open, place the straight edge "K" on the timing marks "M" and "N" on the breaker adapter and check that they line up with the step on the cam. It may be found that timing mark "A" on the distributor finger is not exactly opposite the timing mark "B" on the inside of the front end plate after making the final adjustment by having the straight edge "K" on the cam coinciding with the timing marks "M" and "N." However, any slight variance of the distributor finger timing mark "A" will not affect the operation of the magneto as this is merely used to locate the approximate firing position of the magneto for No. 1 cylinder.

h. The timing hole on the left hand side of the crankcase front section can be used to check for top center of No. 1 piston for magneto timing. Looking through the timing inspection hole, a crank angle degree scale ranging from 0 deg to 35 deg before top center of No. 1 piston is seen etched on the rim of the reduction driving gear. When No. 1 piston is on top center on the compression stroke, the line on the rear of the timing inspection hole will line up with the 0 deg mark on the reduction driving gear scale. When the breaker points open, the reading on this scale should correlate with that reading specified on the engine data plate for magneto advance.

i. If the .001 in. feeler has not been installed, install it at this time by moving the magneto as described above. Tighten the three flange attaching nuts to secure the magneto at this location.

j. Check the setting by turning the propeller shaft backward about a quarter of a revolution. Tap the propeller shaft slowly in the normal direction of rotation stopping when the breaker points commence to open, or when the feeler is released from the breaker points. Observe the angle reading on the timing disk mounted on the starter or on the reduction driving gear scale and check that it agrees with that reading on the engine data plate.

k. If the opening of the magneto points does not coincide with the figures noted on the engine data plate, loosen the magneto attaching nuts, turn the crankshaft to the proper timing setting as indicated on the timing disk, readjust the magneto so that the feeler is just ready to loosen and recheck the timing.

l. When the correct timing has been established, check the attaching nuts for tightness and secure them with cotter pins.

m. If the magneto timing is staggered, it is advisable to install the magneto having the greatest amount of advance first. However, if both magnetos have the same amount of advance, both may be installed, timed, and checked at the same time.

n.

Paragraphs n., o., p. and q.
Deleted in revision dated
20 October 1944

o.

p.

q.

Deleted in revision dated
20 October 1944

r. When both magnetos have been timed satisfactorily, install the plug in the timing inspection hole in the crankcase front section with the copper-asbestos gasket under its head. Tighten and lockwire this plug.

s. Install the breaker housing cover and tighten the two hex-head cap screws which are retained in the cover by circlets. Refer to Figure 247. Check the cap screws for a lock washer under the head of each.

t. Reinstall the distributor block, coil cover, radio shielding and ground terminals as described in Section VIII, paragraph 49.

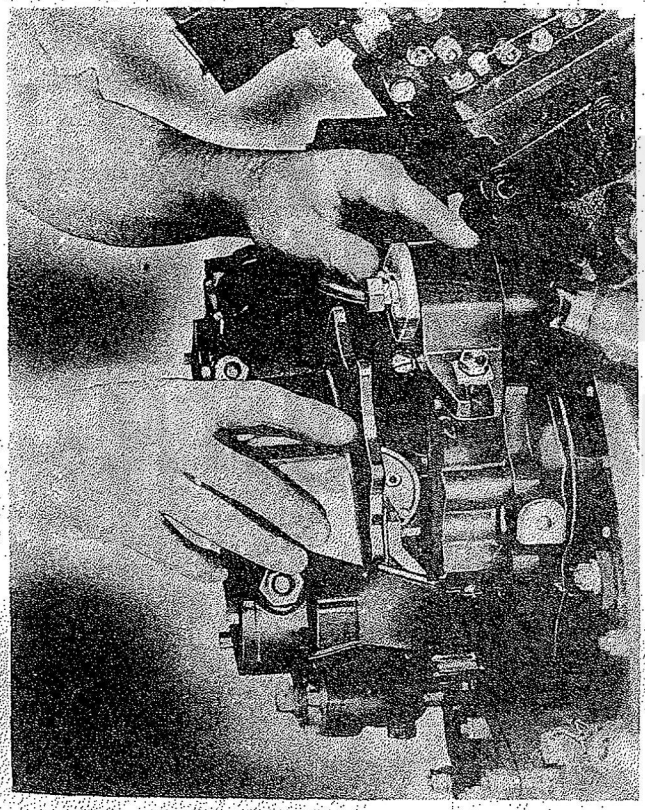

Figure 247—Installing Magneto Coil Cover

27. CHECKING VALVE TIMING.

a. Check the valve timing by installing a top center indicator in the front spark plug hole of No. 1 cylinder. Refer to Figure 248. Mount timing disk (Tool No. 83517) with adapter (Tool No. 800947) on engines equipped with detachable starter dog of 12 teeth and the same timing disk with adapter (Tool No. 83533)

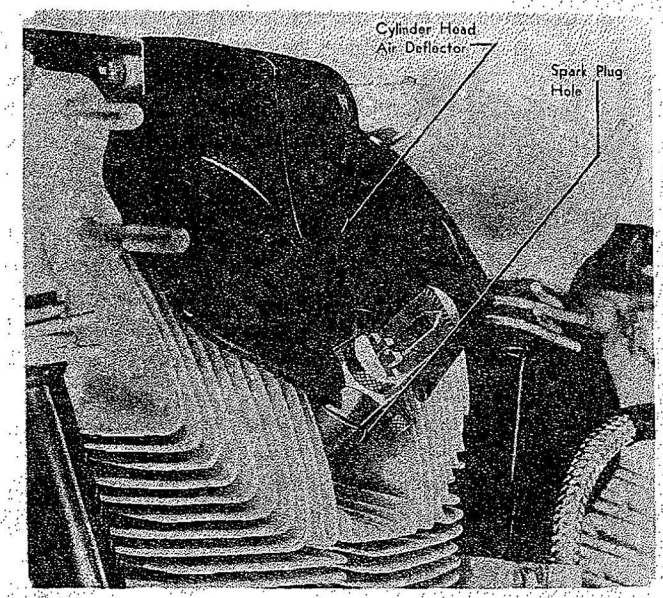

Figure 248—Top Center Indicator

on engines equipped with detachable three-jaw starter dog on the starter mounting pad and secure it with regular starter attaching nuts.

b. Install engine turning hub (Tool No. 82889) on the propeller shaft and note the top center indicator pointer when the crankshaft is turned to determine if the pointer arm is contacting the piston properly. This may be determined by slowly turning the crankshaft until the piston nears the top center position and contacts the pointer arm. If the pointer arm is properly adjusted, the pointer will rise a few graduations as the piston approaches its top center position, pause for a moment and then return to its original position as the piston moves on its downward stroke. If the pointer moves upward off the graduated scale as the piston approaches top center, reverse the crankshaft rotation, remove the top center indicator and readjust the angle of the pointer arm in an upward direction. If the arm does not move, adjust it in a downward position. Repeat this procedure until the top center indicator is adjusted to register properly.

c. Adjust the pointer on the timing disk to read zero when the top center indicator shows the piston in No. 1 cylinder to be on the top center of its compression stroke. This may be checked as follows: Turn the crankshaft in the direction of rotation until the pointer on the top center indicator is in the middle of the graduated scale. Note the reading in degrees indicated by the pointer on the timing disk.

d. Continue to turn the crankshaft until the pointer on the top center indicator has completed its upward stroke and has returned to the point at which the first reading was taken. Again note the reading in degrees indicated by the timing disk pointer. The exact top center position is the point midway between the two timing disk readings.

e. Turn the crankshaft in the opposite direction of rotation for approximately one-quarter turn, then turn it in the direction of rotation to the point midway between the two readings previously obtained and adjust the zero mark on the timing disk to coincide with the pointer.

f. Adjust the clearance of both valves to the timing value specified on the engine data plate.

g. Turn the crankshaft in the direction of rotation until the piston in No. 1 cylinder is 30 to 35 deg before top center on the exhaust stroke.

h. From this point move the crankshaft forward slowly by tapping the turning hub handle until the No. 1 intake rocker roller just contacts the valve stem tip, indicating that the valve is starting to open. Turn the roller. As soon as the roller tightens against the valve tip, note the reading on the timing disk. Continue to turn the shaft forward until the No. 1 exhaust rocker arm roller is free, indicating that the exhaust valve has closed and note the reading on the timing disk. If the cam gears have been meshed properly, the valve clearance adjusted accurately and the check carefully made, the readings obtained should check within a few degrees of the valve timing specifications given on the engine data plate. An error of one tooth made in the meshing of the cam gears will cause the readings obtained to vary considerably from the specified timing.

i. After completing the valve timing check, reset the valves in No. 1 cylinder, following the instructions given regarding the location of the oil holes in the adjusting screws. Pour one-half pint of engine lubricating oil into the rocker boxes and install the rocker box gaskets and covers.

j. Remove the timing disk from the starter mounting pad and reinstall the gasket and cover plate.

k. Remove the top center indicator and reinstall the dummy spark plug. Install the plug in the front section inspection hole and secure with stainless steel lock wire.

28. SPARK PLUGS.

a. Spark plugs which have been sprayed with preservative compound should be thoroughly cleaned, dried out, and bomb tested before installing them in the engine. Plugs should be washed with a good grade of unleaded and uncolored gasoline. After washing, the plugs should be allowed to dry in the open air. Compressed air should not be used to clean or dry spark plugs.

b. The gaps should then be checked and if found greater than .012 in. they should be adjusted to this figure.

c. Check the thickness of the solid type copper spark plug washer and the spark plug type thermocouples. Do not use either type if it does not conform with the following dimension: Minimum thickness of 0.068 in., maximum thickness 0.095 in.

d. Remove the dummy spark plugs.

e. Install solid copper washers on all the spark plugs on the cylinder head threads except for those plugs on which a thermocouple type washer is used.

f. Coat the first three threads from the electrode end lightly with anti-seize compound, specification MIL–T–5544. Install and tighten the spark plugs to the proper torque value. Refer to the Table of Limits in Section XII and to Figure 249.

CAUTION

In lubricating the threads, exercise extreme care so that none of the anti-seize compound is applied to either the ground or center electrodes, or on the electrode end of the plug in a location where, during installation, it may be spread to the ground or center electrodes, since anti-seize compound has a graphite base which is on electrical conductor.

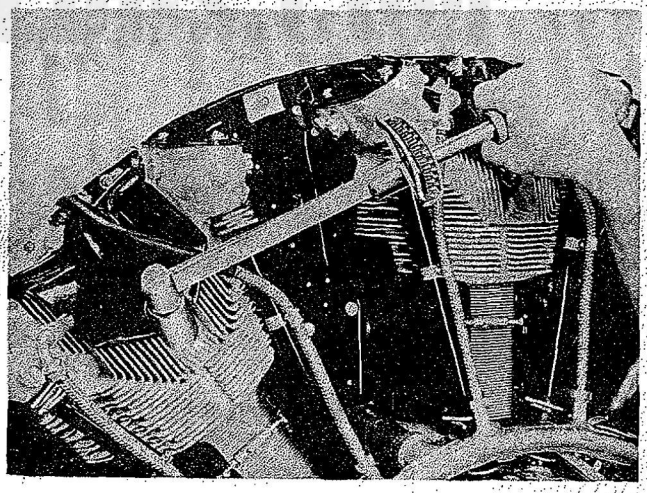

Figure 249—Installing Spark Plug Using Torque Wrench

g. Install a small spark plug shielded terminal elbow copper washer over the contact of each spark plug, clean the contact sleeves with a cloth saturated with carbon tetrachloride. Do not touch them with the

fingers since the salt from any perspiration which might be on the hands will produce arcing and corrosion. Attach the elbows to the plugs.

29. INSTALLING BENDIX-STROMBERG CARBURETOR.

a. To install the carburetor, turn the engine to the front end up position. With the engine in a horizontal position, any foreign particles might easily fall into the induction passage and cause considerable damage to the impeller should the crankshaft be turned.

b. Remove the plate covering the induction passage opening and install a new carburetor adapter gasket.

c. Install the carburetor, along with the adapter attached as a unit to the carburetor, and secure with Elastic stop nuts and spherical seat washers.

d. Install a gasket on each side of the air screen and lock in place on two diagonally opposite studs. Cover the carburetor immediately with oil cloth or some similar material and secure to carburetor with an elastic or bailing wire. This will prevent foreign matter passing the screen into the supercharger section. Keep the carburetor covered until ready to install the carburetor air scoop.

30. TIGHTENING THRUST BEARING NUT.

a. Tighten the thrust bearing nut with the applicable wrench to the specified torque designated in the Table of Limits, Section XII.

b. If, due to the replacement of parts, the measurement is found to be under the low limit, it is permissible to remove the thrust nut and reduce its thickness by grinding the front face, provided not more than .005 in. is removed from a new nut. Once the front face of a thrust nut has been ground, the nut should be identified to prevent subsequent grinding at the next overhaul. Due to the shallow depth of the case hardening of this nut, it is important that the amount of material ground off the face be limited as specified.

c. If the measurement is over the high limit, it will be necessary to install a new thrust nut.

d. A new or reworked thrust nut and ring assembly should be installed in accordance with the instructions given in Section VII, paragraph 13, and Section VIII, paragraph 9.

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SECTION X
TESTING AFTER OVERHAUL

NOTE

AAF PERSONNEL WILL TEST AIRCRAFT ENGINES IN ACCORDANCE WITH INSTRUCTIONS CONTAINED IN AAF T. O. NO. 02-1-4 AND AAF T. O. NO. 02-1-4A.

NAVY PERSONNEL WILL TEST AIRCRAFT ENGINES IN ACCORDANCE WITH INSTRUCTIONS CONTAINED IN NavAer 02-1-508, AERONAUTICAL ENGINE TEST MANUAL AND NAVY SPECIFICATION E-45h.

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Pages 223 to 228 inclusive and figures 250 to 253 inclusive
deleted in revision dated April 15, 1944

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SECTION XI

ACCESSORIES

1. CARBURETOR.

a. For overhaul instructions for the Bendix Stromberg Injection Carburetors with which these engines are equipped, refer to T. O. No. 03-10BA-3 entitled, "Handbook of Overhaul Instructions Injection Carburetors."

2. MAGNETOS.

a. For information covering the magnetos with which these engines are equipped, refer to T. O. No. 03-5DA-3 entitled, "Overhaul Instructions—Aircraft Magnetos" on Scintilla SF9LN-4 magnetos, and to T. O. No. 03-5DC-1 and -2 entitled, respectively, "Handbook of Instructions with Parts Catalog," and "Replacement of Distributor Rotor," on American-Bosch magnetos.

3. SPARK PLUGS.

a. For general information regarding spark plugs, refer to T. O. No. 03-5E-1 entitled "Spark Plugs—Use and Reconditioning."

4. STARTER.

a. For complete information regarding replacement, maintenance and overhaul of aircraft engine starters, refer to the applicable Technical Order of the 03-5C series.

5. GENERATOR.

a. For information regarding the generator, refer to the applicable Technical Order of the 03-5A series.

6. PROPELLER GOVERNOR.

a. For information regarding service and overhaul of the propeller governor, refer to Technical Order 03-20CA-2.

7. VACUUM PUMP.

a. For information concerning the vacuum pump, refer to the applicable Technical Order of the 03-30A series.

8. HYDRAULIC PUMP.

a. For information concerning the hydraulic pump, refer to the applicable Technical Order of the 03-30C series.

9. FUEL PUMP.

a. For information concerning the hydraulic pump, refer to the applicable Technical Order of the 03-10E series.

10. TACHOMETER.

a. For information regarding the tachometer, refer to the applicable Technical Order of the 05-5 series.

11. GUN SYNCHRONIZERS.

a. For information on gun synchronizers, refer to the applicable Technical Order of the 11-20 series.

12. OIL FILTER.

a. In addition to the instructions previously given in this Handbook concerning Cuno Automatic oil filters, refer to T. O. No. 03-1-32, entitled "Handbook of Instructions for Cuno Filters."

NOTE:

The Technical Orders listed above are for reference by Army Air Forces and British personnel only.

SECTION XII

TABLE OF LIMITS

Reference No.	Chart No.	Description	Minimum	Maximum
		Dual Accessory Drive		
6		Vacuum Pump Shaft and Accessory Drive Shaft Spline Side Clearance	.001L	.010L
8		Accessory Drive Idler Gear and Bushing.....Dia.	.002L	.008L
9		Accessory Drive Idler Gear .....End Clearance	.006L	.040L
10		Accessory Drive Idler Gear Bushing .....Dia.	.001T	.003T
11		Accessory Drive Intermediate Gear and Intermediate Shaft Gear .....Backlash	.004	.020
12		Accessory Drive Intermediate Shaft and Bushing.....Dia.	.002L	.008L
13		Accessory Drive Intermediate Shaft .....End Clearance	.006L	.040L
14		Accessory Drive Intermediate Shaft Bushing ..... Dia.	.001T	.003T
15		Upper Vacuum Pump Drive Gear and Bushing.....Dia.	.002L	.008L
16		Upper Vacuum Pump Drive Gear ..... End Clearance	.014L	.050L
17		Upper Vacuum Pump Drive Gear Bushing.....Dia.	.001T	.003T
18		Accessory Drive Idler Gear and Upper and Lower Vacuum Pump Drive Gears .....Backlash	.004	.020
19		Lower Vacuum Pump Drive Gear and Front Bushing..... Dia.	.002L	.008L
20		Lower Vacuum Pump Drive Gear and Rear Bushing..... Dia.	.004L	.010L
21		Lower Vacuum Pump Drive Gear.....End Clearance	.011L	.050L
22		Lower Vacuum Pump Drive Gear Front Bushing and Housing .....Dia.	.001T	.003T
23		Lower Vacuum Pump Drive Gear Rear Bushing and Cover.....Dia.	.002T	.004T
24		Upper Vacuum Pump Drive Gear Bushing .....Dia. *For involute coupling drive. (Standard and special ratio accessory drive shafts.)*	.002T	.004T
25		Upper Vacuum Pump Drive Gear and Bushing..... Dia. *For involute coupling drive. (Standard and special ratio accessory drive shafts.)*	.004L	.010L
26		Upper Vacuum Pump Drive Gear ..... End Clearance *For special accessory drive shaft with a ratio of 1.636:1.*	.011L	.050L
500		Dual Accessory Drive Housing to Supercharger Rear Cover Attaching Nut .....Tightening Torque *Threads must be lubricated with oil.*	135 in.-lb	150 in.-lb
501		Dual Accessory Drive Housing Flange to Dual Accessory Drive Housing Cover Attaching Nut .....Tightening Torque *Threads must be lubricated with oil.*	135 in.-lb	150 in.-lb
		Longitudinal and Accessory Drive Sections		
1		Rocker Roller Hub and Pin .....Dia.	.001T	.002L
2		Rocker Roller Hub and Rocker Roller.....Dia.	.0015L	.020L
3		Rocker Roller Hub and Rocker Arm .....Side Clearance	Rivet Tight	
4		Rocker Roller and Rocker Arm .....Side Clearance	.0095L	.050L
5		Rocker Bearing and Rocker Box—Side Clearance before Clamping....	.0005T	.015L
5A		Rocker Bearing—Inner Races Clamped.....End Clearance	Clamp Tight	.010L
6		Rocker Arm Bearing and Rocker .....Dia.	.0018T	.000
7		Rocker Arm Bearing and Rocker Bolt .....Dia.	.000	.004L
8		Rocker Bolt and Cylinder Head .....Dia.	.0005L	.005L

Reference No.	Chart No.	Description	Minimum	Maximum
10		Rocker Arm Bearing—Internal End Play—Out of Rocker Arm	.008L	.019L
11		Rocker Arm Bearing—Internal End Play in Rocker Arm with Rocker Arm Bolt Inserted in Bearing	Free	.012
		VALVE SPRING LOAD (Three-Spring Arrangement)		
		Spring — *Wire Dia.* — *At Height*		
12		Inner — .135 in. — 1.438 in.	49.5 lb	.....
		Intermediate — .162 in. — 1.531 in.	67.5 lb	.....
		Outer — .192 in. — 1.406 in.	90.0 lb	.....
13		Intake Valve and Valve Guide — Center Dia.	.002L	.008L
		End Dia.	.002L	.010L
14		Exhaust Valve and Valve Guide — Center Dia.	.0035L	.008L
		End Dia.	.0035L	.010L
		Minimum diameter of exhaust valve stem neck—.667. (This diameter must blend in with the stem diameter at a point not less than 4 in. from the tip end of valve.) Minimum permissible diameter of exhaust valve stem—.005 in. under production base dimension which is .6825 in.		
15		Intake Valve Guide and Cylinder Head — Dia.	.001T	.003T
16		Exhaust Valve Guide and Cylinder Head — Dia.	.003T	.0045T
17		Valve Seat in Cylinder Head — Intake Dia.	.009T	.013T
		Exhaust Dia.	.0095T	.0135T
18		Governor Drive Shaft Bushing and Crankcase — Dia.	.001T	.003T
19		Governor Drive Shaft and Bushing — Dia.	.002L	.006L
20		Governor Drive Gear and Governor Intermediate Drive Gear — Backlash	.004	.026
21		Piston Groove No. 1 (Top) and Ring — Side Clearance	.011L	.013L
21A		Piston Groove No. 1 (Top) and Ring— (Wedge Type) — Side Clearance	.004L	.009L
		Side Clearance must be measured in four equally spaced places and is obtained when wedge ring OD is flush with the piston thrust faces at the skirt diameter.		
22		Piston Groove No. 2 and Ring — Side Clearance	.011L	.013L
22A		Piston Groove No. 2 and Ring— (Wedge Type) — Side Clearance	.006L	.011L
		Side Clearance must be measured in four equally spaced places and is obtained when wedge ring OD is flush with the piston thrust faces at the skirt diameter.		
23		Piston Groove No. 3 and Ring — Side Clearance	.008L	.010L
23A		Piston Groove No. 3 and Ring— (Wedge Type) — Side Clearance	.006L	.011L
		Side Clearance must be measured in four equally spaced places and is obtained when wedge ring OD is flush with the piston thrust faces at the skirt diameter.		

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Reference No.	Chart No.	Description	Minimum	Maximum
24		Piston Groove No. 4 and Ring ..... Side Clearance	.011L	.013L
24A		Piston Groove No. 5 and Ring ..... Side Clearance	.011L	.013L
25		Piston Groove No. 6 and Ring ..... Side Clearance	.006L	.008L
26		Piston Ring—Compression and Oil Rings ..... Gap	.044	.....
26A		Piston Ring (Chrome Plate Ring) ..... Gap	.069	.....
27		Piston Pin and Piston ..... Dia.	.000	.004L
28		Piston Pin Bushing and Piston Pin ..... Dia.	.002L	.008L
29		Piston and Cylinder Barrel (Center of Skirt) ..... Dia.	.023L	.041L
29A		Piston Wear (Center of Skirt) ..... Dia.	.....	.004
30		Cylinder Barrel Bore ..... Taper	.....	.010
		Wear	.....	.010
31		Cylinder Barrel Bore ..... Out of Round	.....	.005
32		Piston Pin Bushing and Connecting Rod ..... Dia.	.004T	.0065T
33		Master Rod and Bearing ..... Dia.	.0025T	.0045T
33A		Master Rod and Bearing (Loose Pre-Fit Bearing) ..... Dia.	.001L	.0035L
34		Master Rod and Knuckle Pin Bushing ..... Side Clearance	.007L	.030L
35		Articulated Rod and Knuckle Pin Bushing ..... Dia.	.004T	.0065T
36		Knuckle Pin and Bushing ..... Dia.	.0027L	.006L
37	17	Master Rod and Knuckle Pin ..... Tight Fit	.0005T	.0015T
37A	17	Master Rod and Knuckle Pin ..... Loose Fit	.0005L	.002L
38	17	Master Rod Oil Seal Disk Lugs and Knuckle Pin Locking Plate Lugs ..... Side Clearance	.005L	.030L
39	17	Master Rod Oil Seal Disk Spring ..... Load at .32 in. Height	6 lb	10 lb
40	17	Knuckle Pin Locking Plate and Master Rod Oil Seal Disk (Aluminum) ..... Dia.	.002L	.008L
40A	17	Knuckle Pin Locking Plate and Master Rod Oil Seal Disk (Steel) ..... Dia.	.0005L	.005L
41	17	Master Rod and Knuckle Pin Locking Plate ..... Dia.	.0005T	.003L
42	17	Master Rod and Master Rod Spacer ..... Dia.	.0005L	.008L
43	17	Crankpin Bearing ..... End Play *Engines with tight fit knuckle pins—end play to be measured with master rod in extreme forward position.*	.010L	.045L
43A	17	Crankpin Bearing ..... End Play *Engines with loose fit knuckle pins—end play to be measured with master rod in extreme forward position.*	.018L	.055L
44	17	Valve Tappet Spring—Wire Dia. .063 in. ..... Load at 2.14 in. Height	9 lb	10.5 lb
45	17	Valve Tappet and Ball Socket ..... Dia.	.0012L	.0027L
46	17	Valve Tappet and Guide ..... Dia.	.001L	.0035L
47	17	Valve Tappet Guide and Crankcase Front Section ..... Dia.	.000	.002L
48	17	Valve Tappet Roller and Bushing ..... Dia.	.001L	.005L
49	17	Valve Tappet and Roller and Roller Bushing ..... Side Clearance	.0075L	.015L
50	17	Valve Tappet Roller Pin and Guide ..... Side Clearance	.005L	.016L

Reference No.	Chart No.	Parts and Descriptions		Minimum (in.)	Maximum (in.)
*79a.	17	Propeller Shaft Thrust Bearing Retainer and Bearing—(Close Clearance)	dia	.0005T	.0005L
79b.	17	Propeller Shaft Thrust Bearing Retainer and Bearing (Close Clearance) (When using thrust bearing part number 21D93.)	dia	.0016T	.0004L
80.	17	Propeller Shaft Thrust Bearing and Retainer	Side Clearance	.0001T	.0059L
81.	17	Propeller Shaft Thrust Bearing Nut Oil Seal Ring	Side Clearance	.003L	.015L
82.	17	Propeller Shaft Thrust Bearing Nut Oil Seal Ring—(Hand Fit)	Gap	.003	.015
84.	17	Spline Side Clearance, Movement of Propeller Hub on Propeller Shaft Measured at 15 in. Radius from Center of Propeller Shaft		.....	.040
85.	17	Allowable Runout of Propeller Shaft Between Threads and Splines at Forward End when in Position in Engine		.012 Full Indicator Reading	
*86.	17	Propeller Shaft—Total Radial Looseness		.....	.015
87.	17	Propeller Shaft and Sleeve	dia	.0015T	.0045T
88.	17	Propeller Shaft Sleeve and Front Bushing	dia	.0015T	.0035T
89.	17	Crankshaft Front End Propeller Shaft Bushing	dia	.0025L	.006L
90.	17	Allowable Runout of Crankshaft at Front and Rear Propeller Shaft Bushing Locations when Supported at Main Front and Rear Bearings		.006 Full Indicator Reading	
91.	17	Propeller Shaft and Rear Bushings	dia	.0015T	.0045T
92.	17	Crankshaft Front End and Propeller Shaft Rear Bushing	dia	.003L	.007L
96.	17	Crankcase Front Section and Crankcase Main Front Section	dia	.002T	.006L
*98.	17	Crankpin Bearing and Crankpin—Diameter (Select at Assembly)	dia	.0038L	.0065L
*98a.	17	Crankpin Bearing and Crankpin (Loose Pre-Fit Bearing)	dia	.004L	.0065L
*98b.	17	Crankpin	Out of Round	.....	.0015
*98c.	17	Crankpin	Taper	.....	.001
99.	17	Front Counterweight and Stop		.0455L	.072L
100.	17	Front Crankshaft and Counterweight Pin Bushing	dia	.001T	.0025T
101.	17	Front Counterweight and Bushing	dia	.0015T	.003T
102.	17	Rear Crankshaft and Counterweight Pin Bushing	dia	.001T	.0025T
103.	17	Rear Counterweight and Bushing	dia	.0015T	.003T
104.	17	Rear Counterweight and Stop		.0215L	.046L
105.	17	Crankcheck to Cap Screw	Stretch	.008	.009
106.	17	Crankshaft Front and Crankshaft Rear (Before Tightening Cap Screw)	dia	.001T	.002L
107.	17	Crankcase Main Rear and Rear Bearing Ring	dia	.004T	.006T
108.	17	Crankcase Main Rear Bearing Ring and Bearing	dia	.004L	.008L
*108a.	17	Crankcase Rear Main Bearing Ring and Bearing—Close Clearance	dia	.0005T	.0005L
109.	17	Crankshaft Rear and Bearing	dia	.001T	.0024T
110.	17	Crankshaft End Play on Crankcase Main Section		.014L	.051L
111.	17	Accessory Drive and Starter Coupling and Rear Crankshaft	dia	.000	.001T
112.	17	Generator Gear Bushing and Supercharger Rear Cover	dia	.0015T	.0035T
113.	17	Generator Gear and Bushing	dia	.001L	.008L
114.	17	Diffuser Plate Vanes and Supercharger Front Housing		.005T	.012T
115.	17	Generator Gear	End Clearance	.007L	.045L
116.	17-18	Generator and Magneto Drive Oil Seal Spring, Wire Diameter, .091 in. Tension at .36 in. Height		8.5 lb	.....
117.	17	Generator Drive Oil Seal Collar and Generator Gear	dia	.0005T	.0015T
118.	17	Supercharger Intermediate Gear 7:1 Ratio and Generator Gear	Backlash	.006	.025
119.	17	Intermediate Impeller Drive Shaft Rear Bushing and Supercharger Rear Cover	dia	.001T	.003T
120.	17	Impeller Clutch and Pinion Shaft and Intermediate Impeller Drive Shaft Rear Bushing	dia	.0005L	.005L
124.	17	Intermediate Impeller Drive Shaft Propeller End Bushing and Supercharger Rear Housing	dia	.001T	.0045T
128.	17	Supercharger Intermediate Gear and Accessory Drive Gear	Backlash	.006	.025
129.	17	Supercharger Intermediate Gear and Impeller Drive Shaft Gear 7:1 Ratio	Backlash	.004	.018

*Refer to notes.

Reference No.	Chart No.	Parts and Descriptions		Minimum (in.)	Maximum (in.)
130.	17	Accessory Drive Gear Spring Wire Dia .225 in. Tension at 1.544 in. Height		530 lb	625 lb
131.	17	Impeller Shaft Retainer and Oil Seal Ring	Side Clearance	.002L	.011L
132.	17	Impeller Shaft Retainer Oil Seal Ring Gap—Hand Fit		.006	.008
133.	17	Accessory Drive and Starter Shaft—(Machine in Assembly)	Side Clearance	.020L	.040L
134.	17	Accessory Drive and Starter Shaft Bushing and Supercharger Rear Cover	dia	.005T	.007T
135.	17	Accessory Drive and Starter Shaft and Bushing	dia	.002L	.005L
136.	17	Accessory Drive and Starter Shaft and Starter Coupling (12 Jaw)	dia	.0005L	.003L
137.	17	Accessory Drive and Starter Shaft to Starter Coupling and Spacer	dia	.005L	.025L
138.	17	Accessory Drive and Starter Shaft and Impeller Shaft Rear Bushing	dia	.002L	.006L
139.	17	Impeller Drive Shaft Gear and Front Rear Bushing	dia	.002T	.004T
140.	17	Accessory Drive and Starter Shaft and Impeller Shaft Front Bushing	dia	.0025L	.006L
141.	17	Impeller Drive Shaft Gear and Rear Oil Seal Sleeve	dia	.000	.004L
142.	17	Supercharger Housing Rear Sleeve and Supercharger Rear Housing	dia	.001T	.003T
143.	17	Impeller Oil Seal Ring and Impeller Shaft Oil Seal Sleeve Front and Rear	Side Clearance	.005L	.009L
144.	17	Impeller Oil Seal Ring—Front and Rear Gap—Hand Fit		.010	.0135
145.	17	Impeller Drive Shaft Gear	End Clearance	.012L	.017L
146.	17	Impeller Drive Shaft Gear and Impeller Shaft Oil Seal Front Sleeve	dia	.000	.004L
147.	17	Accessory Drive and Starter Shaft and Coupling Ring	Side Clearance	.002L	.008L
148.	17	Starter Shaft and Coupling Ring—Gap		.0006	.004
*149.	17	Impeller and Front Supercharger Housing	Side Clearance	.050L	.....
*150.	17	Impeller and Diffuser Plate	Side Clearance	.030L	.066L
151.	18	Magneto Drive Oil Seal Collar and Magneto and Gun Synchronizer Drive Shaft	dia	.0005T	.0025T
152.	18	Magneto Drive Shaft Bushing and Supercharger Rear Cover	dia	.001T	.003T
153.	18	Magneto Drive Shaft and Bushing	dia	.001L	.008L
154.	18	Magneto Drive Shaft	End Clearance	.005L	.050L
155.	18	Gun Synchronizer Drive Shaft Thrust Bearing and Supercharger Rear Cover	dia	.001T	.003T
156.	18	Magneto Drive Shaft Gear and Synchronizer Drive Gear	Backlash	.004	.025
157.	18	Magneto Drive Gear and Pump Drive Gear	Backlash	.004	.025
158.	18	Magneto and Gun Synchronizer Drive Shaft and Plug	dia	.0005T	.0035T
159.	18	Supercharger Front Housing Breather Relief Valve Spring Wire dia .030 in., Tension at .50 in. Height		35 lb	56 lb
160.	18	Fuel Pump Drive Shaft Support and Bushing	dia	.001T	.003T
161.	18	Fuel Pump Drive Shaft and Bushing	dia	.001L	.005L
162.	18	Fuel Pump Drive Shaft Support and Supercharger Rear Cover	dia	.000	.004L
163.	18	Fuel Pump Drive Shaft and Plug	dia	.0005T	.002T
164.	18	Gun Synchronizer Drive Shaft Thrust Bushing and Supercharger Rear Cover	dia	.001T	.003T
165.	18	Fuel Pump Drive Shaft	End Clearance	.011L	.040L
166.	18	Oil Filter Bushing and Oil Filter	dia	.000	.0025L
167.	18	Pump Drive Gear and Magneto Drive Gear	Backlash	.005	.025
168.	18	Pump Drive Gear and Accessory Drive Gear	Backlash	.005	.025
169.	18	Accessory Drive Gear and Accessory Gear	Backlash	.004	.025
170.	18	Oil Pump Drive Shaft and Cover	dia	.002L	.015L
171.	18	Oil Pump Drive Shaft and Oil Pump Body	dia	.002L	.015L
172.	18	Oil Pump Drive Shaft and Oil Pump End Plate	dia	.002L	.015L
173.	18	Oil Pump Suction Drive Gear and Oil Pump Body	dia	.001L	.007L
174.	18	Oil Pump Pressure Gears and Body	End Clearance	.0035L	.013L
175.	18	Oil Pump Suction Gears and Body	End Clearance	.0065L	.012L
*176.	18	Oil Suction Pump Drive Gear and Idler Gear	Backlash	.004	.020

*Refer to notes.

Reference No.	Chart No.	Parts and Descriptions		Minimum (in.)	Maximum (in.)
*177.	18	Oil Pressure Pump Drive Gear and Driven Gear	Backlash	.004	.020
178.	18	Oil Pump Driven Pressure Gear and Pump Body	dia	.002L	.010L
179.	18	Oil Pump Driven Pressure Gear and Pump Cover	dia	.002L	.010L
180.	18	Oil Pump Idler Gear Shaft and Pump Body	dia	.001T	.0025T
181.	18	Oil Pump Idler Gear Shaft and Pump End Plate	dia	.0005T	.002L
182.	18	Oil Pump Idler Gear and Idler Gear Shaft	dia	.0015L	.008L
183.	18	Pump Drive Gear and Bushing	dia	.001L	.008L
184.	18	Pump Drive Gear Bushing and Supercharger Rear Cover	dia	.001T	.0035T
185.	18	Pump Drive Gear	End Clearance	.028L	.060L
186.	18	Pump Drive Gear and Plug	dia	.0005T	.0035T
187.	18	Tachometer Drive Oil Seal Thrust Spring-Wire dia .048 in., Tension at .50 in. Height		4.50 lb	5.50 lb
188.	18	Tachometer Drive Shaft Bushing and Oil Pump Cover	dia	.001T	.003T
189.	18	Tachometer Drive Shaft and Large Bushing	dia	.001L	.006L
190.	18	Tachometer Drive Shaft Bushing and Tachometer Drive Housing Cover	dia	.001T	.003T
191.	18	Tachometer Drive Shaft and Small Bushing	dia	.002L	.005L
192.	18	Tachometer Drive Shaft Housing and Bushing	dia	.001T	.0035T
193.	18	Tachometer Drive Shaft and Sleeve Shoulder End	dia	.0005T	.0035T
			Outer End—dia	.0015L	.0035T
194.	18	Tachometer Drive Shaft Sleeve and Bushing	dia	.003L	.006L
195.	18	Oil Pump Drive Shaft and Tachometer Drive Shaft	Backlash	.004	.020
196.	18	Oil Pressure Relief Valve and Body	dia	.002L	.0045L
197.	18	Oil Pressure Relief Valve Spring Wire dia .063 in., Tension at 1.406 in. Height		20 lb	24 lb
198.	18	Fuel Pump Tachometer and Spare Drive Shaft	End Clearance	.020L	.060L
199.	18	Tachometer Drive Shaft and Oil Seal Thrust Spring Bushing	dia	.001T	.0025T
200.	18	Tachometer Drive Oil Seal Thrust Spring Retainer and Bushing	dia	.003L	.008L
201.	18	Oil Suction Pump Idler Gear and Body	End Clearance	.0095L	.0125L
202.	18	Oil Pressure Pump Drive Gear and Body	dia	.0007L	.0077L
203.	18	Tachometer Drive Bushing I. D. Propeller End and Tachometer Drive Shaft		.002L	.005L
204.	18	Oil Pressure Pump Idler Gear and Body	End Clearance	.0055L	.014L
205.	18	Oil Pressure Relief Valve Spring—Wire dia .063 in., Tension at 1.38 in.	Height	6 lb	8 lb
206.	18	Oil Pressure Relief Valve Body and Oil Pressure Relief Valve	dia	.000	.003L
207.	18	Oil Pump Check Valve Spring—Wire dia .047 in., Tension at 2 in. Height		3.50 lb	4.00 lb
208.	18	Oil Pressure Pump Drive Gear and Oil Pump Cover	dia	.002L	.010L
209.	18	Oil Pressure Pump Drive Gear and Body	End Clearance	.0055L	.014L
210.	18	Oil Suction Pump Idler Gear and Body	dia	.0012L	.0065L
211.	18	Oil Pump Drive Shaft and Oil Pressure Pump Drive Gear	dia	.0005L	.002L
212.	18	Tachometer Drive Shaft Housing and Tachometer Drive Shaft Housing Cover	dia	.0005T	.0035L
213.	18	Oil Pump Drive Shaft and Oil Suction Pump Idler Gear	Backlash	.004	.020
214.	18	Tachometer Drive Gear Shaft and Oil Pressure Pump Drive Gear	dia	.0005L	.002L
215.	18	Tachometer Drive Gear Shaft and Tachometer Drive Shaft	Backlash	.004	.020
216.	18	Tachometer Drive Gear Shaft and Tachometer Drive Oil Seal Thrust Spring Retainer		.003L	.005L
217.	18	Oil Pressure Pump Idler Gear and Body	dia	.001L	.0067L
218.	18	Oil Pressure Pump Idler Gear and Oil Pressure Pump Drive Gear	Backlash	.004	.020
219.	18	Oil Pump Drive Shaft and Body	End Clearance	.0095L	.015L
220.	18	Oil Pressure Pump Idler Gear and Body (Hole)	dia	.002L	.010L
221.	18	Oil Pressure Pump Idler Gear and Oil Pump Cover (Hole)		.002L	.010L

*Refer to notes.

Reference No.	Chart No.	Parts and Descriptions		Minimum (in.)	Maximum (in.)
222.	18	Oil Suction Pump Idler Gear Shaft and Body—(Hole)	dia	.001T	.0025T
223.	18	Oil Suction Pump Idler Gear Shaft and Oil Suction Pump Idler Gear	dia	.0015L	.008L
224.	18	Oil Pump Cover and Tachometer Drive Bushing O. D. Propeller End	dia	.001T	.003T
225.	18	Tachometer Drive Bushing I. D. Anti-Propeller End and Drive Shaft	dia	.002L	.005L
226.	18	Tachometer Drive Gear Shaft and Mechanical Drive Shaft	Backlash	.004	.020
227.	18	Oil Pump Check Valve Body and Oil Pump Check Valve	dia	.020L	.036L
228.	18	Oil Pump Check Valve Body and Oil Pump Check Valve Oil Seal Ring	Side Clearance	.002L	.006L
229.	18	Oil Pump Check Valve Body and Pump Body	dia	.001T	.0025T
230.	18	Oil Pump Check Valve Oil Seal Ring—Gap		.0065	.020
231.	17	Impeller and Shaft (Impeller must be a Tight Fit on Splines)			
248.	17	Propeller Shaft Thrust Bearing Spacer Oil Seal Ring—Gap (Hand Fit)		.012	.013
249.	17	Propeller Shaft Thrust Bearing Spacer Oil Seal Ring	Side Clearance	.001L	.010L
250.	17	Stationary Reduction Gear Support and Sleeve	dia	.005T	.007T
251.	17	Reduction Gear Pinion and Bushing	Side Clearance	.004L	.010L
252.	17	Reduction Gear Pinion and Bushing	dia	.0013L	.0035L
253.	17	Reduction Driving Gear and Pinion	Backlash	.011	.027
254.	17	Reduction Gear Pinion Bushing and Reduction Gear Pinion Carrier	Small End dia	.0015L	.006L
			Large End dia	.002L	.006L
255.	17	Stationary Reduction Gear and Pinion	Backlash	.011	.025
256.	17	Propeller Shaft and Thrust Bearing Spacer (16:9 Reduction)	dia	.001T	.001L
256A.	17	Propeller Shaft Flange to Reduction Gear Pinion Carrier	dia	.0015T	.001L
257.	17	Intermediate Impeller Drive Shaft Propeller End Bushing and Supercharger Intermediate Gear Shaft	dia	.0005L	.004L
258.	17	Supercharger Intermediate Gear Shaft and Intermediate Impeller Drive Shaft Rear Bushing and Supercharger Rear	End Clearance	.023L	.055L
259.	17	Crankshaft Rear End and Counterweight Bearing Rear	dia	.001T	.003T
260.	17	Counterweight Rear (Crankshaft) Bearing and Counterweight Rear Bushing	dia	.0025L	.0035L
261.	17	Supercharger Rear Housing and Supercharger Rear Housing Sleeve	dia	.000T	.003T
262.	17	Crankshaft Plug and Crankshaft	dia	.001T	.003L
264.	17	Propeller Shaft	End Play	.011	.025
*265.	17	Starter Coupling—locating dimension		1.714	1.719
266.	18	Gun Synchronizer Impulse Generator Drive Shaft	End	.0055L	.0185L
266a.	18	Gun Synchronizer Impulse Generator Drive Shaft (Bronze Gear)	End	.004L	.019L
267.	18	Gun Synchronizer Impulse Generator Drive Shaft—Support and Bushings	dia	.001T	.003T
268.	18	Gun Synchronizer Impulse Generator Drive Shaft and Bushings	dia	.001L	.004L
269.	17	Crankshaft and Crankshaft Breather Support (Rear)	dia	.001T	.003L
270.	17	Crankshaft and Crankshaft Breather Support (Front)	dia	.001L	.003L
271.	17	Crankshaft Breather Support and Crankshaft Breather Tube	dia	.0005L	.0025L
272.	18	Tachometer Drive Pinion and Bushings	dia	.001L	.005L
273.	18	Tachometer Drive Pinion and Tachometer Drive Shaft	Backlash	.004	.020
274.	18	Tachometer Drive Pinion Bushings and Housing and Housing Adapter	dia	.001T	.003T
275.	18	Oil Filter Bushing and Supercharger Rear Cover	dia	.0015T	.003T
276.	18	Oil Pump Drive Gear Spring Wire dia .071 in., Tension at 1.78 in. Height		8 lb	10 lb
277.	17	Cam Drive Gear and Pinion (Spline Fit)		.001T	.010L
278.	17	Propeller Shaft Length—Thrust Nut to Center of Hole		8.547	8.577
279.	17	Crankpin Plug and Crankpin	dia	.0005L	.002L
280.	18	Valve Clearance		.010	
		If this clearance aligns oil hole in adjusting screw with split in rocker arm, turn screw in direction to increase valve clearance until hole is closed off .09 in. or until .017 in. valve clearance is			

*Refer to notes.

Reference No.	Chart No.	Description		Minimum	Maximum
218		Oil Pressure Pump Idler Gear and Oil Pressure Pump Drive Gear	Backlash	.004	.020
219		Oil Pump Drive Shaft and Body	End Clearance	.0065L	.015L
220		Oil Pressure Pump Idler Gear and Body (Hole)	Dia.	.002L	.010L
221		Oil Pressure Pump Idler and Oil Pump Cover (Hole)	Dia.	.002L	.010L
222	18	Oil Suction Pump Idler Gear Shaft and Body—(Hole)	Dia.	.001T	.0025T
223	18	Oil Suction Pump Idler Gear Shaft and Oil Suction Pump Idler Gear	Dia.	.0015L	.008L
224	18	Oil Pump Cover and Tachometer Drive Bushing OD Propeller End	Dia.	.001T	.003T
225	18	Tachometer Drive Bushing ID Anti-Propeller End and Drive Shaft	Dia.	.002L	.005L
226	18	Tachometer Drive Gear Shaft and Tachometer Drive Shaft	Backlash	.004	.020
227	18	Oil Pump Check Valve Body and Oil Pump Check Valve	Dia.	.020L	.036L
228	18	Oil Pump Check Valve Body and Oil Pump Check Valve Oil Seal Ring	Side Clearance	.002L	.006L
229	18	Oil Pump Check Valve Body and Pump Body	Dia.	.001T	.0025T
230	18	Oil Pump Check Valve Oil Seal Ring	Gap	.0065	.020
231	17	Impeller and Shaft (Impeller must be a tight on splines)			
248	17	Propeller Shaft Thrust Bearing Spacer Seal Ring—(Hand Fit)	Gap	.012	.013
249	17	Propeller Shaft Thrust Bearing Spacer Oil Seal Ring	Side Clearance	.001L	.010L
250	17	Stationary Reduction Gear Support and Sleeve	Dia.	.005T	.007T
251	17	Reduction Gear Pinion and Bushing	Side Clearance	.004L	.010L
252	17	Reduction Gear Pinion and Bushing	Dia.	.0013L	.0035L
253	17	Reduction Driving Gear and Pinion	Backlash	.011	.027
254	17	Reduction Gear Pinion Bushing and Reduction Gear Pinion Carrier	Small End Dia.	.0005L	.006L
			Large End Dia.	.0015L	.006L
255	17	Stationary Reduction Gear and Pinion	Backlash	.011	.025
256	17	Propeller Shaft and Thrust Bearing Spacer (16:9 Reduction)	Dia.	.001T	.001L
257	17	Intermediate Impeller Drive Shaft Propeller End Bushing and Supercharger Intermediate Gear Shaft	Dia.	.0005L	.006L
258	17	Supercharger Intermediate Gear Shaft and Intermediate Impeller Drive Shaft Rear Bushings and Supercharger Rear	End Clearance	.023L	.055L
259	17	Crankshaft Rear End and Counterweight Bearing Rear	Dia.	.001T	.003T
260	17	Counterweight Rear (Crankshaft) Bearing and Counterweight Rear Bushing	Dia.	.0025L	.0035L
261	17	Supercharger Rear Housing and Supercharger Rear Housing Sleeve	Dia.	.000	.003T
262	17	Crankshaft Plug and Crankshaft	Dia.	.001T	.003L
264	17	Propeller Shaft	End Play	.0056	.025
265	17	Starter Coupling—locating dimension *After obtaining clearance per Reference No. 133 machine spacer "R" to obtain this dimension with the starter coupling located in extreme "in" position forward against accessory shaft with accessory shaft resting against forward thrust ring.*		1.699	1.704
266	18	Gun Synchronizer Impulse Generator Drive Shaft	End	.0055L	.0185L
266A	18	Gun Synchronizer Impulse Generator Drive Shaft (Bronze Gear)	End	.004L	.019L
267	18	Gun Synchronizer Impulse Generator Drive Shaft—Support and Bushings	Dia.	.001T	.003T
268	18	Gun Synchronizer Impulse Generator Drive Shaft and Bushings	Dia.	.001L	.004L
269	17	Crankshaft and Crankshaft Breather Support (Rear)	Dia.	.001T	.003L

Reference No.	Chart No.	Description		Minimum	Maximum
270	17	Crankshaft and Crankshaft Breather Support (Front)	Dia.	.001L	.003L
271	17	Crankshaft Breather Support and Crankshaft Breather Tube	Dia.	.0005L	.0025L
272	18	Tachometer Drive Pinion and Bushings	Dia.	.001L	.005L
273	18	Tachometer Drive Pinion and Tachometer Drive Shaft	Backlash	.004	.020
274	18	Tachometer Drive Pinion Bushings and Housing and Housing Adapter	Dia.	.001T	.003T
275	18	Oil Filter Bushing and Supercharger Rear Cover	Dia.	.0015T	.003T
276	18	Oil Pump Drive Gear Spring—Wire Dia. .071 in.	Load at 1.78 in. Height	8 lb	10 lb
277	17	Cam Drive Gear and Pinion (Spline Fit)		.001T	.010L
278	17	Propeller Shaft Length—Thrust Nut to Center of Hole		8.547	8.577
279	17	Crankpin Plug and Crankpin	Dia.	.0005L	.002L
280	18	Valve Clearance		.010	.....
		If this clearance aligns oil hole in adjusting screw with split in rocker arm, turn screw in direction to increase valve clearance until hole is closed off .09 in. or until .017 in. value clearance is obtained, whichever occurs first. In no case must .017 in. clearance be exceeded.			
281	17	Accessory Drive and Starter Shaft and Oil Retaining Plug	Dia.	.000	.0015T
282	17	Starter Coupling Spacer and Oil Retaining Plug	Dia.	.002L	.005L
283	17	Starter Coupling Spring—Wire Dia. .125 in.	Load at .89 in. Height	52.2 lb	63.8 lb
284	17	Faces on Knuckle Pin may vary in relation to Master Rod from .000 to .004 in. above but must be in line with each other within .002 in.			
285	18	Valve Spring (Outer)—Wire Dia. .192 in.	Load at 1.406 in. Height	.....	90 lb
286	18	Valve Spring (Inner)—Wire Dia. .188 in.	Load at 1.561 in. Height	.....	112 lb
287	18	Gun Synchronizer Drive Shaft Support and Bushing	Dia.	.001T	.003T
288	18	Gun Synchronizer Drive Shaft and Bushing	Dia.	.001L	.008L
289	18	Gun Synchronizer Drive Shaft	End	.014L	.055L
290	18	Gun Synchronizer Cam and Roller (With Plunger in Locked Position)		.002L	.010L
291	18	Gun Synchronizer Roller and Plunger	Dia.	.001L	.004L
292	18	Gun Synchronizer Roller and Plunger	Side	.003L	.012L
293	18	Gun Synchronizer Plunger and Upper Housing	Dia.	.0005L	.005L
294	18	Gun Synchronizer Plunger and Lower Housing	Side	.0005L	.020L
295	17	Reduction Gear Pinion Carrier and Propeller Shaft	Dia.	.0015T	.001L
296		Piston Pin Plug and Piston Pin	Dia.	.001L	.004L
297		Piston Pin Plug and Cylinder Barrel	Side Clearance	.009L	.0035L
298		Rocker Hub Bolt Bushing and Cylinder Head	Dia.	.0009T	.0024T
299		Generator Drive Gear	End Clearance	.020L	.060L
300		Generator Drive Gear and Intermediate Drive Gear	Backlash	.004	.....
301		Intermediate Impeller Drive Shaft	End Clearance	.021L	.060L
302		Exhaust Valve Guide Retainer Sleeve and Spacer Retainer	Dia.	.001L	.005L
303		Exhaust Port Sleeve and Cylinder Head	Dia.	.0062T	.0092T
304		Exhaust Valve Oil Seal Spacer and Retainer	Dia.	.0008L	.0012T
305		Exhaust Valve Guide and Cylinder Head (Note: Exhaust valve guide and seat concentricity must be within .002 inch maximum.)	Dia.	.003T	.0045T
306		Exhaust Valve Guide and Valve	Center Dia.	.0035L	.008L
			End Dia.	.0035L	.010L
307		Exhaust Valve Guide and Retainer Sleeve	Dia.	.001L	.005L
308		Exhaust Valve Spacer Retainer and Valve Guide	Dia.	.002L	.006L
309		Piston Groove No. 4 and Rings (Simplex)	Side Clearance	.0065L	.009L

Reference No.	Chart No.	Description	Minimum	Maximum
310		Piston Ring Groove No. 4 (Simplex)....Gap *Ring gaps must be on piston pin side. Stagger gaps about 1-1/2 inches apart with gaps of 1st and 3rd rings in line.*	.043	.....
500	17	Carrier Ring to Propeller Shaft Attaching Bolt....Tightening Torque *Threads must be lubricated with oil.*	750 in.-lb	850 in.-lb
501	17	Crankcase Front Cover Attaching Nut and Screw, also Stationary Reduction Gear Attaching Stud Nut ....Tightening Torque *Threads must be lubricated with oil.*	350 in.-lb	400 in.-lb
502	17	Impeller Drive Shaft Gear Nut....Tightening Torque *Threads must be lubricated with oil.*	3200 in.-lb	3700 in.-lb
503	17	Valve Clearance Adjusting Screw Lockscrew (with tapered head)....Tightening Torque	135 in.-lb	150 in.-lb
504	17	Reduction Gear Drive Pinion Lock Nut....Tightening Torque *Threads must be lubricated with oil.*	350 in.-lb	400 in.-lb.
505	17	Propeller Shaft Hydro-Oil Connection Cover Nut ....Tightening Torque *Use lubriplate on threads.*	2000 in.-lb	2200 in.-lb
506	17	Oil Pump Attaching Nut ....Tightening Torque *Threads must be lubricated with oil.*	85 in.-lb	100 in. lb
507		Crankcase Attaching Bolt ....Tightening Torque *Threads must be lubricated with oil.*	500 in.-lb	550 in.-lb
		Two-Speed Supercharger (Plate Clutch Type)		
1		Impeller Shaft Drive Multi-Plate Clutch Gear 10:1 Ratio and Bushing ....Dia.	.002L	.006L
2		Intermediate Impeller Driveshaft and Impeller Shaft Drive Multi-Plate Clutch Gear 10:1 Ratio....Dia.	.000	.035L
3		Intermediate Impeller Drive Shaft and Piston 10:1 Ratio....Dia.	.001L	.006L
4		Intermediate Impeller Drive Shaft and Intermediate Impeller Drive Gear Bushing....Dia.	.001L	.005L
5		Intermediate Impeller Drive Gear and Bushing ....Dia.	.002T	.004T
6		Intermediate Impeller Drive Shaft and Sun Gear Bushing....Dia.	.001L	.008L
7		Intermediate Impeller Drive Sun Gear and Bushing ....Dia.	.002L	.008L
8		Intermediate Impeller Drive Shaft and Rear Bushing....Dia.	.0005L	.007L
9		Intermediate Impeller Drive Shaft—(Machine in Assembly) (Accessory Drive Gear and Impeller Shaft Multi-Plate Clutch Gear Side Clearance, Reference No. 19, is affected by this Adjustment) ....End Play	.020L	.....
10		Impeller Drive Multi-Plate Clutch Piston (7.14:1 Ratio) and Intermediate Impeller Drive Shaft Rear Bushing....Dia.	.0005L	.002L
11		Impeller Drive Multi-Plate Clutch Piston and Oil Seal Ring 7.14:1 Ratio....Side Clearance	.0065L	.014L
12		Impeller Drive Multi-Plate Clutch Piston Oil Seal Ring 7.14:1 Ratio—(Hand Fit)....Gap	.003	.004
13		Impeller Shaft Drive Multi-Plate Clutch Piston 10:1 Ratio and Oil Seal Ring....Side Clearance	.006L	.015L
14		Impeller Drive Multi-Plate Clutch Piston Oil Seal Ring 10:1 Ratio....Gap	.003	.010
15		Intermediate Impeller Drive Shaft Plug Check Valve Spring—Wire Dia. .020 in. ....Load at .50 in. Height	.22 lb	.....
16		Intermediate Impeller Drive Shaft Plug Check Valve and Oil Distributor Plug ....Dia.	.002L	.012L
17		Intermediate Impeller Drive Gear and Generator Gear ....Backlash	.006	.020

Reference No.	Chart No.	Description		Minimum	Maximum
18		Intermediate Impeller Drive Gear and Pinion and Accessory Drive Gear	Backlash	.006	.020
19		Accessory Drive Gear and Impeller Shaft Multi-Plate Clutch Gear	Clearance	.020L	.....
		Adjust intermediate impeller drive shaft end play, Reference No. 9, to obtain this clearance.			
20		Impeller Shaft Drive Multi-Plate Clutch Gear and Impeller Drive Shaft Gear 10:1 Ratio	Backlash	.003	.018
21		Impeller Shaft Drive Multi-Plate Clutch Gear and Impeller Drive Multi-Plate Piston Lug	Side Clearance	.035L	.050L
22		Intermediate Impeller Drive Gear and Pinion and Drive Pinion	Backlash	.004	.015
23		Intermediate Impeller Drive Sun Gear and Pinion	Backlash	.004	.015
24		Intermediate Impeller Drive Shaft and Intermediate Impeller Drive Pinion Bushing	Dia.	.0015L	.007L
25		Intermediate Impeller Drive Pinion and Bushing	Dia.	.0005L	.006L
26		Impeller Drive Multi-Plate Clutch Piston (7.14:1 Ratio) and Two-Speed Clutch Thrust Washer Lock	Dia.	.002T	.0045T
27		Impeller Drive Multi-Plate Clutch Sleeve (7.14:1 Ratio) and Supercharger Rear Cover	Dia.	.001L	.003T
28		Impeller Drive Multi-Plate Clutch Housing and Sleeve	Dia.	.003L	.010L
29		Supercharger Clutch Oil Control Valve and Housing	Dia.	.0005L	.0025L
30		Supercharger Clutch Oil Control Valve Housing and Supercharger Rear Cover	Dia.	.0005T	.0015L
31		Supercharger Clutch Oil Control Valve Spring, .47 in. OD— Wire Dia. .055 in.	Load at 1.63 in. Height	4.75 lb	.....
			Load at 1.08 in. Height	11.40 lb	.....
32		Impeller Clutch Release Spring (7.14:1 Ratio)— Wire Dia. .093 in.	Load at .75 in. Height	18 lb	.....
33		Impeller Clutch Release Spring (10:1 Ratio)— Wire Dia. .105 in.	Load at .50 in. Height	16.74 lb	.....
34		Intermediate Impeller Drive Shaft Oil Distributor Plug and Intermediate Impeller Drive Shaft	Dia.	.000	.0015T
35		Intermediate Impeller Drive Shaft Oil Distributor Plug and Intermediate Impeller Drive Shaft	Dia.	.000	.002T
36		Intermediate Impeller Drive Pinion and Bushing	Side Clearance	.006L	.030L
37		Impeller Drive Shaft Gear 10:1 Ratio	End Clearance	.012L	.017L
38		Accessory Drive Shaft—(Machine at Assembly)	Side Clearance	.020L	.040L
500		Intermediate Impeller Drive Shaft Pipe Plug	Tightening Torque	350 in.-lb	400 in.-lb
		Threads must be lubricated with oil.			

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Reference No.	Chart No.	Parts and Descriptions		Minimum (in.)	Maximum (in.)
9.	19	Governor Drive Coupling Gear and Governor Drive Idler Gear and Booster Pump Housing Cage	dia	.004L	.010L
10.	19	Torque Arm and Torque Indicator Overrunning Valve	dia	.001L	.008L
11.	19	Torque Indicator Valve Oil Seal Ring	Gap	.002	.008
12.	19	Torque Indicator Valve and Oil Seal Ring	Side Clearance	.002	.010
13.	19	Crankcase Front Section and Torque Indicator Housing	Side Fit	.002T	.006L
16.	19	Torque Arm and Stationary Reduction Gear	Backlash	.002	.010
16a.	19	Torque Arm and Stationary Reduction Gear	Backlash	.000	.006
17.	19	Torque Arm Support and Ball Thrust Bearing	dia	.0004L	.005L
18.	19	Torque Arm Support and Torque Arm Bearing Assembly (using exact size balls)	dia	.001L	.004L

TIGHTENING TORQUE VALUES

Special cases and exceptions to this table are listed in the preceding pages of this section.

STANDARD STUDS, BOLTS, SCREWS, AND CAP SCREWS							
				Torque Values			
				Driving Stud		Tightening Nut, Screw, or Cap Screw	
Name	Size of Thread Nut End	Min. Diam of Thread Root or Neck (In.)	Min. Rockwell Hardness	Minimum In. Lb	Maximum In. Lb	Minimum In. Lb	Maximum In. Lb
Button-Head Screw	10-32	.1467	B-50	.....	.....	20	25
Button-Head Screw	12-24	.1585	B-50	.....	.....	25	30
Studs, Bolts, Screws and Cap Screws	10-32	.1467	C-19	.....	.....	35	40
"	12-24	.1585	C-19	.....	.....	45	50
"	1/4-28	.180	C-26	50	70	80	85
"	5/16-24	.229	C-26	100	150	160	175
"	3/8-24	.285	C-26	200	275	225	250
"	7/16-20	.331	C-26	300	425	350	375
"	1/2-20	.387	C-26	500	700	550	600
"	9/16-18	.436	C-26	750	975	825	875
"	5/8-18	.493	C-26	1100	1400	1125	1200
STANDARD PRACTICES FOR SPECIAL APPLICATIONS							
Cyl Hold-Down Stud	3/8-24	.313	C-32	325	450	350	375
Cyl Hold-Down Cap Screw	7/16-20	.330	C-26	.....	.....	375	400
Cyl Hold-Down Stud	7/16-20	.331	C-32	400	550	425	450
Rocker Hub Bolt	9/16-18	.488	C-26	.....	.....	300	375
Spark Plug	18 mm	.....	.....	.....	.....	300	360
Water Injection Discharge Valve	9/16-18	.....	.....	.....	.....	200	210
Spark Plug Insert	1.000-14	.....	.....	.....	.....	1200	1400
Fuel Injection Nozzle Insert	5/8-18	.....	.....	.....	.....	400	450
Exhaust Flange To Cylinder Nut	5/16-24	.....	.....	.....	.....	160	175
Exhaust Flange Check Nut	5/16-24	.....	.....	.....	.....	90	100

VALVE SEAT AND VALVE FACE ANGLES

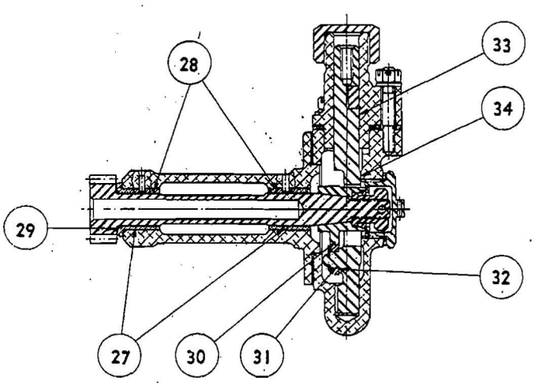
In order that the valve angles can be set off more accurately and ground more efficiently, the following are specified:

	Valve Seat Angle, Intake and Exhaust	Valve Face Angle, Intake and Exhaust
R-1820-40, -40B, -54, -60, -65, -71, -73, -87, -91, -97	45°0′-±15′	44°0′-±15′

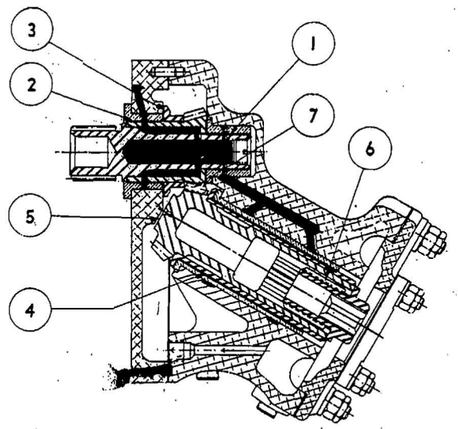
LIMITS AND LUBRICATION CHART

R-1820-65, -40, -60, -71, -73, -87, -97 Model Engines

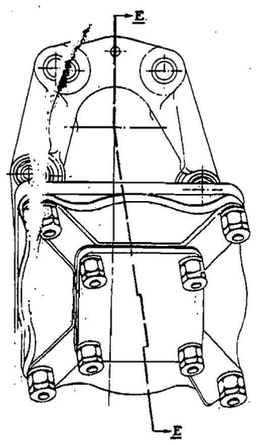
DUAL ACCESSORY DRIVE AND GUN SYNCHRONIZER



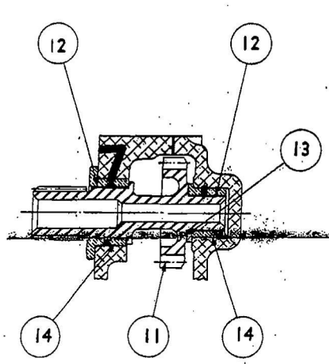
SECTION THRU GUN SYNCHRONIZER



SECTION E - E



ANGLE ACCESSORY DRIVE



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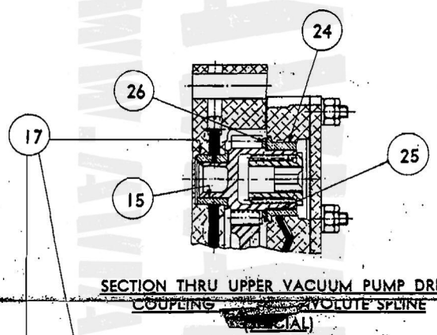
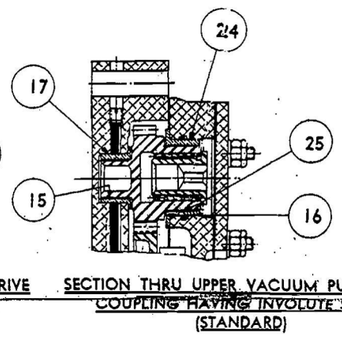


SECTION THRU UPPER VACUUM PUMP DRIVE COUPLING HAVING INVOLUTE SPLINE (SPECIAL)



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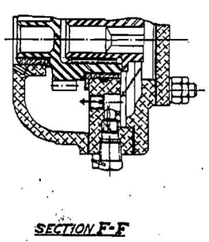

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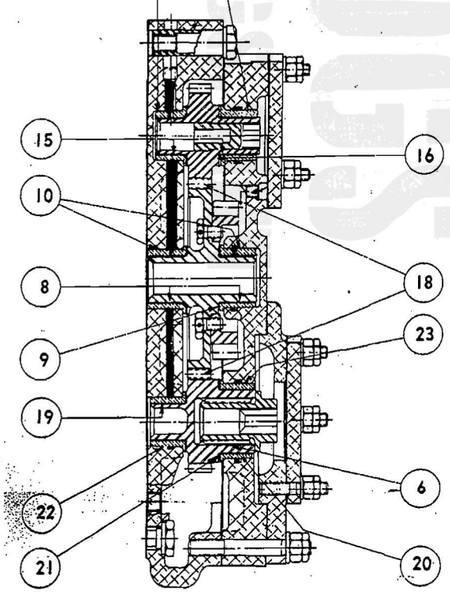
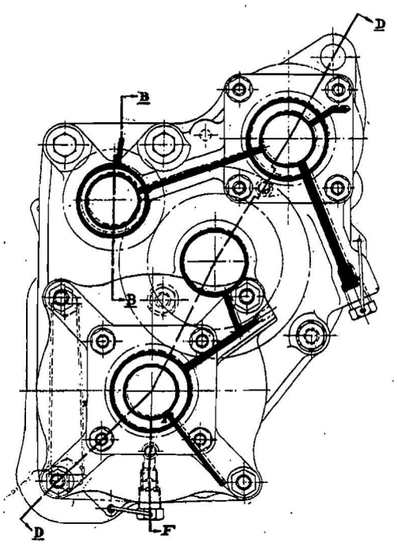


SECTION D - D



DUAL ACCESSORY DRIVE

Figures contained on this chart are reference numbers only. Limits, (fits, clearance, etc.) corresponding to these are included in this section.

LEGEND

- PRESSURE SYSTEM
- SCAVENGE SYSTEM

Scale measurement should never be taken from these views for any mechanical purpose.

LIMITS AND LUBRICATION CHART

FOR

Model R-1820-40, -40B, -54, -60, -71, -87, -97, G202A, and G205A Engines

LONGITUDINAL SECTION

Manufactured by

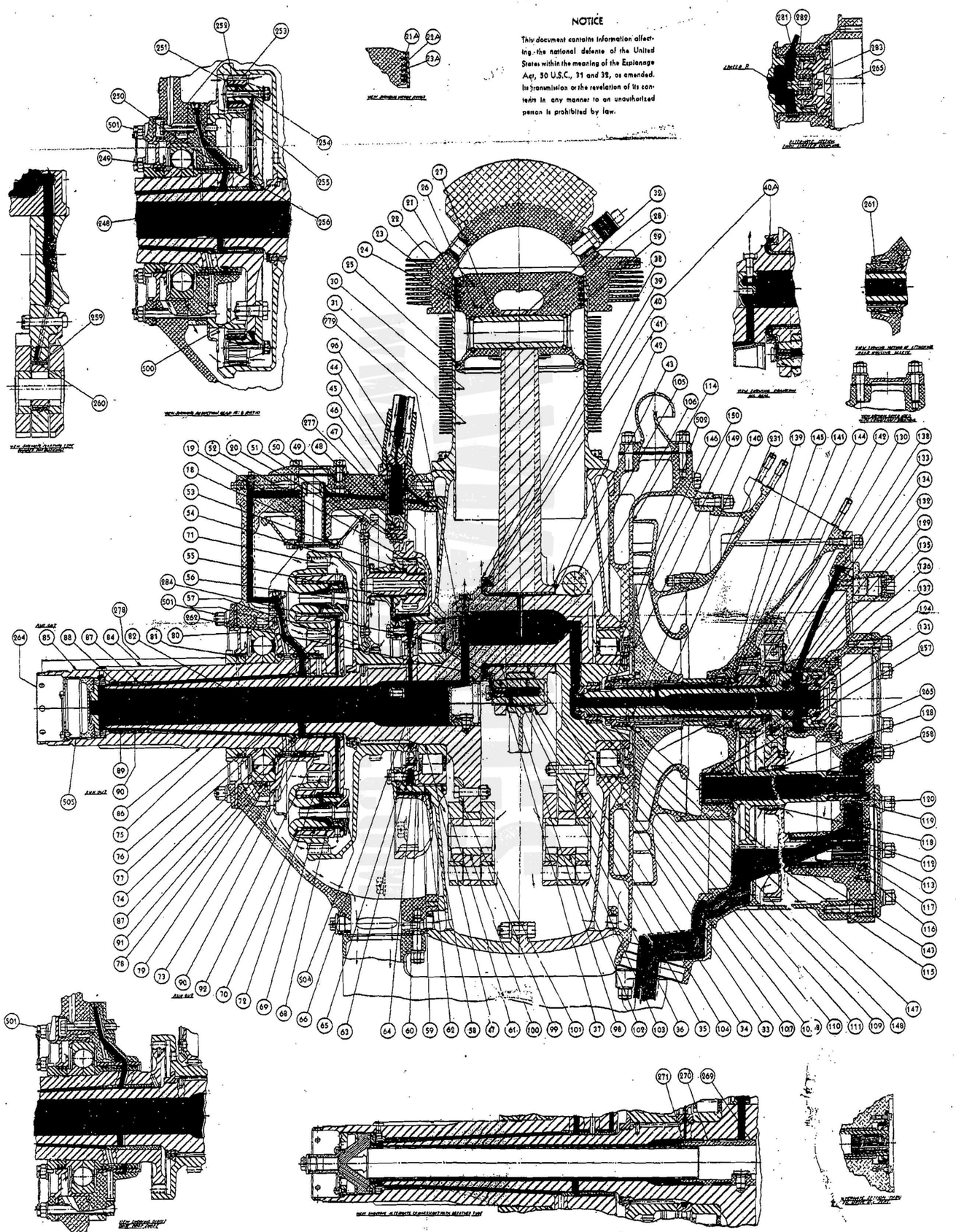
WRIGHT AERONAUTICAL CORPORATION

Chart No. 17

1945 EDITION

NOTICE

This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, 50 U.S.C., 31 and 32, as amended. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.



FIGURES CONTAINED ON THIS CHART ARE REFERENCE NUMBERS ONLY. LIMITS (FITS, CLEARANCE, ETC.) CORRESPONDING TO THESE WILL BE FOUND IN AN02-35GC-3.

LEGEND

- PRESSURE OIL
- SCAVENGE OIL

THIS LIMITS AND LUBR... PART OF AN02-35GC-3. SHOULD NEVER BE ... VIEWS FOR ANY ME...

...CHART IS A ...LE MEASUREMENTS ...EN FROM THESE ...NICAL PURPOSES.

LIMITS AND LUBRICATION CHART

FOR

Model R-1820-40, -40B, -54, -60, -71, -87, -97, G202A, and G205A Engines

ACCESSORY DRIVES SECTION

Manufactured by

WRIGHT AERONAUTICAL CORPORATION

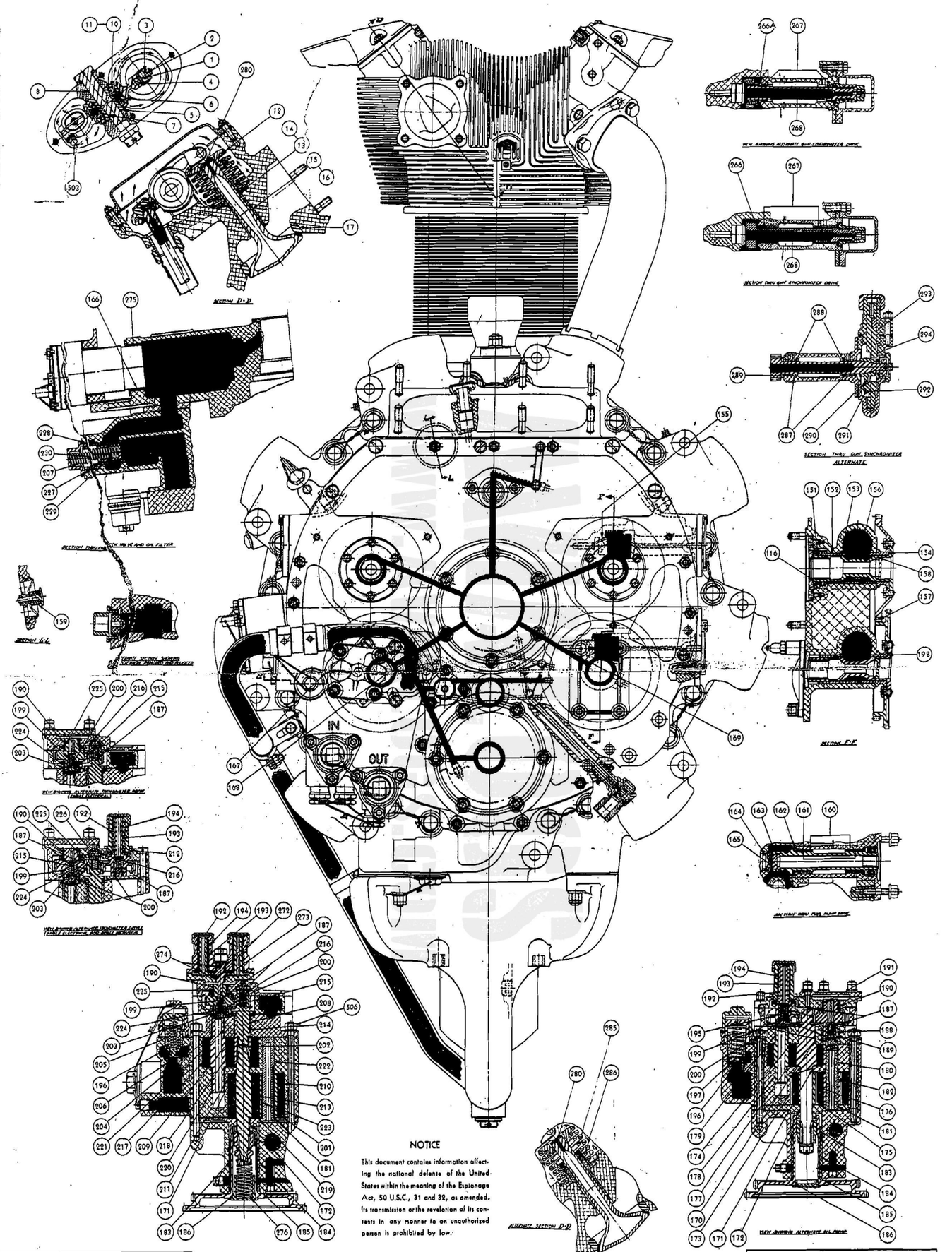
Chart No. 18

1945 EDITION

Revised 10 May 1945

247

AN 02-35GC-3



NOTICE

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LEGEND

PRESSURE OIL

SCAVENGE OIL

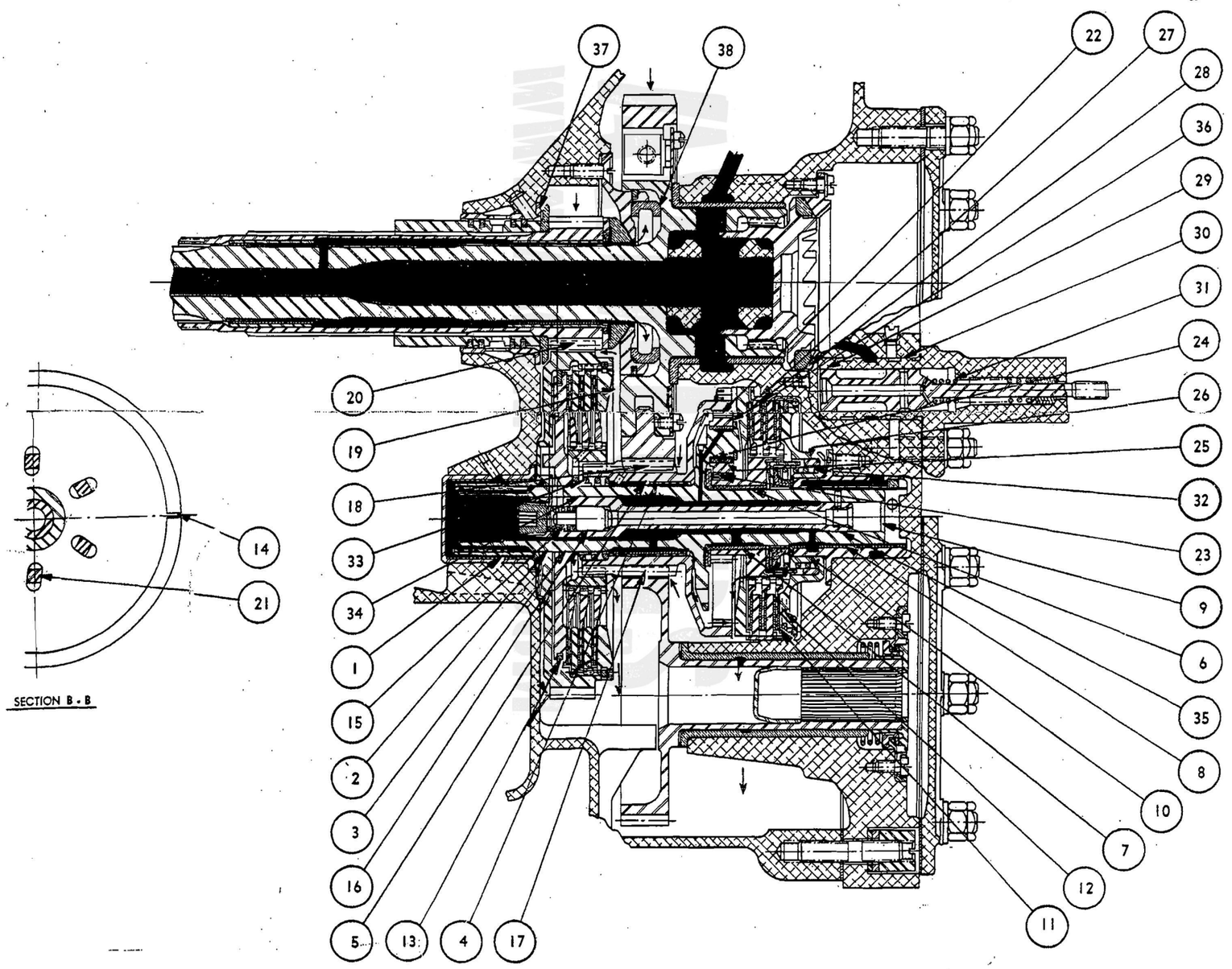
FIGURES CONTAINED ON THIS CHART ARE REFERENCE NUMBERS ONLY. LIMITS (FITS, CLEARANCE, ETC.) CORRESPONDING TO THESE WILL BE FOUND IN AN02-35GC-3.

THIS LIMITS AND LUBRICATION CHART IS A PART OF AN02-35GC-3. SCALE MEASUREMENTS SHOULD NEVER BE TAKEN FROM THESE VIEWS FOR ANY MECHANICAL PURPOSES.

LIMITS AND LUBRICATION CHART

R-1820-40, -87 Model Engines

TWO SPEED SUPERCHARGER (PLATE CLUTCH TYPE)



SECTION B-B

Figures contained on this chart are reference numbers only. Limits, (fits, clearance, etc.) corresponding to these are included in this section.

LEGEND.

PRESSURE SYSTEM

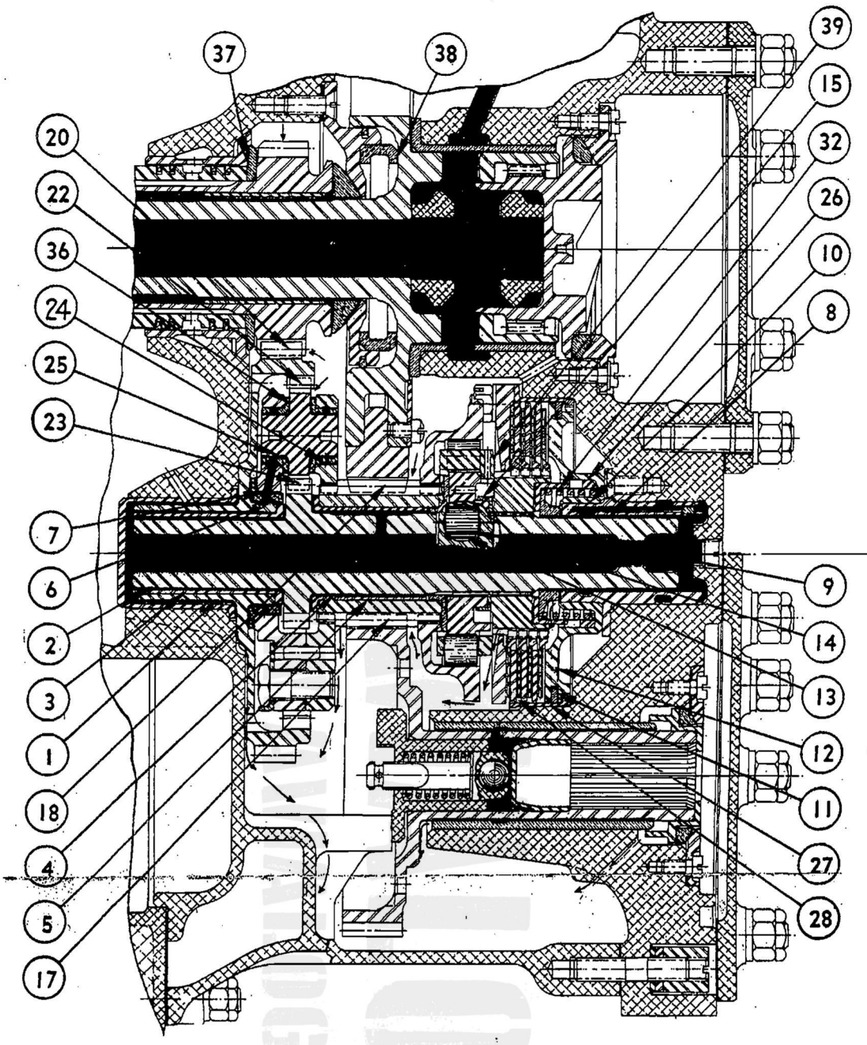
SCAVENGE SYSTEM

Scale measurement should never be taken from these views for any mechanical purpose.

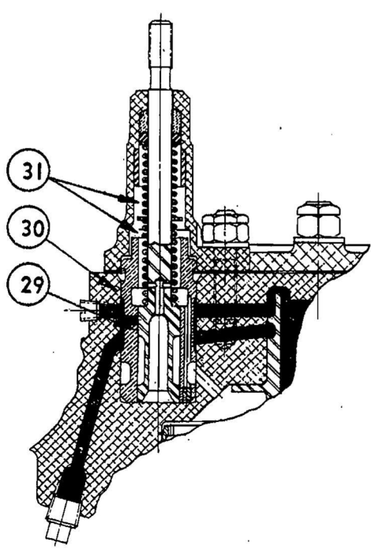
LIMITS AND LUBRICATION CHART

R-1820-40, -60, -87 Model Engines

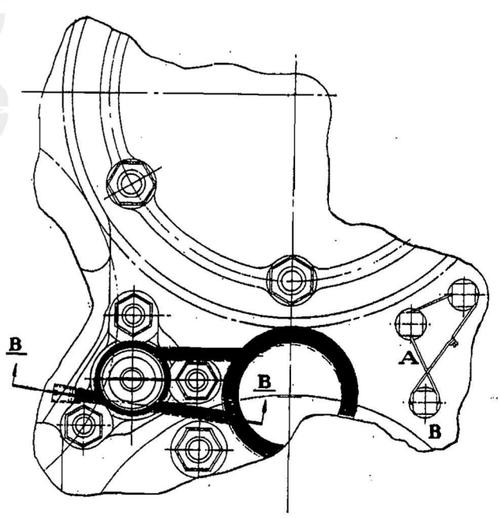
TWO SPEED SUPERCHARGER (ROLLER CLUTCH TYPE)



7.134:1 & 10.04:1 RATIOS



SECTION B-B



VIEW SHOWING
SUPERCHARGER CLUTCH OIL CONTROL VALVE

Figures contained on this chart are reference numbers only. Limits, (fits, clearance, etc.) corresponding to these are included in this section.

LEGEND

- PRESSURE SYSTEM
- SCAVENGE SYSTEM

Scale measurement should never be taken from these views for any mechanical purpose.

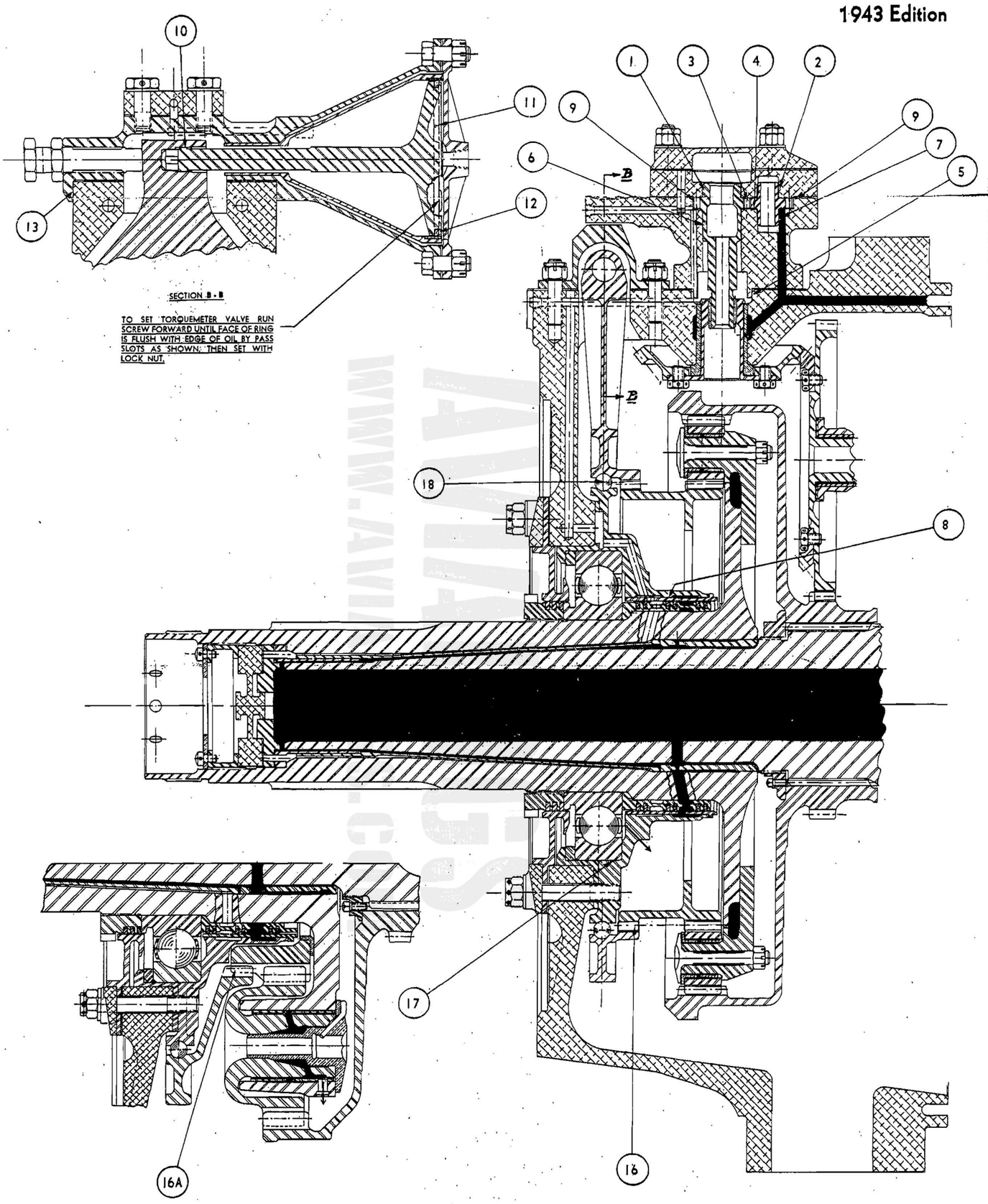
LIMITS AND LUBRICATION CHART

FOR

Model R-1820-40, -40B, -60, -65, -71, -73, -87, -97, G202A, and G205A Engines

TORQUEMETER

1943 Edition



SECTION THRU 3:2 REDUCTION GEAR

SECTION THRU 16:9 REDUCTION GEAR

Figures contained on this chart are reference numbers only. Limits, (fits, clearance, etc.) corresponding to these will be found in AN 02-35-1.

LEGEND

- PRESSURE OIL
- SCAVENGE OIL

This limits and lubrication chart is a part of AN 02-35-1. Scale measurements should never be taken from these views for any mechanical purposes.

APPENDIX 1

American and British Aeronautical Nomenclature Referred to in this AN Handbook

American	*British Equivalent*	*Definition*
Aircraft	Aircraft	Any weight-carrying device designed to be supported by the air, either by buoyancy or by dynamic action. In Britain used only as a collective plural, and in the United States as either a singular or a collective plural.
Airdrome, airfield, or airport	Aerodrome	A definite and limited area of ground or water intended to be used in connection with the arrival, departure, and servicing of aircraft.
Airplane	Aeroplane	A mechanically driven aircraft heavier than air, fitted with fixed wings, and supported by the dynamic action of the air.
Angle, propeller-blade, or blade angle	Blade angle	The acute angle between the chord of a propeller section and the plane of rotation.
Antifriction Bearing (See Bearing, ball)		
Area, total propeller—disk	Disk area	The area of the circle described by the tips of the blades.
Automatic mixture control (Brit.) (See Control, altitude mixture)		
Axis, vertical	Normal axis or vertical axis	An axis at right angles to the horizontal plane of the longitudinal and lateral axes, and passing through their intersection.
Ball bearing (See Bearing, ball)		
Bearing, antifriction, ball bearing, or roller bearing	Ball bearing or roller bearing	A bearing designed to eliminate sliding friction by balls or rollers, which have only rolling contact with the cones and races.
Cap screw (See Screw, cap)		
Carburetor	Carburettor or carburetter	A mechanical device for mixing liquid fuel and air in the proper proportions to form a combustible mixture.
Check valve (See Valve, check)		
Clevis	Fork joint, knuckle joint end, or clevis	A device, usually consisting of a forked piece of metal with the ends perforated to receive a pin, used to fasten the end of a rod to another part of a structure.
Club, test	Test fan	A dummy propeller used in testing engines.
Cone, split, or split wedge	Collet	Cone section used to lock a valve spring collar onto a valve stem.

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American	*British Equivalent*	*Definition*
Cone, union	Union nipple	A joint that is brazed onto the end of a pipe.
Control, altitude mixture	Mixture control, automatic mixture control, or altitude control	A device on a carburetor for regulating the proportions of air and fuel supplied to an engine at different altitudes.
Cotter pin (See Pin, cotter)		
Efficiency, propeller	Net efficiency	The ratio of the thrust power to the input power of a propeller.
Engine, geared	Geared motor or geared engine	An engine in which the power developed is transmitted to the propeller shaft through gears.
Engine or power plant	Aero-engine	An engine used to provide the motive power for an aircraft.
Exhaust manifold (See Ring, exhaust collector)		
Exit	Egress or exit	A passage out of a place.
Fillister screw (See Screw, fillister)		
Filter, screen or strainer (oil)	Filter	A porous material or a unit through which engine oil is passed to cleanse and strain it.
Flat-head screw (See Screw, flat-head)		
Friction, skin	Surface friction	The tangential component of fluid force at a point on a surface.
Fuel (See Gasoline)		
Fuel gage (See Gage, fuel)		
(to) Gall	(to) Fret	To damage or wear by an oscillating motion, as in the case of splines.
Gasket	Joint, washer, or gasket	A sheet or ring of packing used for pipe joints, engine heads, and similar purposes.
Gasoline, "gas," or fuel	Petrol or fuel (preferable)	A volatile, inflammable, liquid hydrocarbon mixture used as a fuel.
Geared engine (See Engine, geared)		
Generator	Dynamo	A machine by which mechanical energy is changed into electrical energy.
Gross weight (See Weight, gross)		
Ignition harness (Brit.) (See Shield)		
Kerosene	Paraffin, kerosene, or petroleum	An illuminating oil distilled from petroleum.

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American	*British Equivalent*	*Definition*
Lean	Weak	Of a mixture of air and gasoline vapor, deficient in the gasoline vapor.
Left	Port	Situated to the left, looking in the direction of motion of an aircraft.
Locknut (Brit.) (See Palnut)		
Lock ring (See Ring, lock)		
Lock washer (See Washer, lock)		
Lock wire (See Wire, lock)		
Manifold pressure (See Pressure, manifold)		
Manifold pressure regulator (See Regulator, manifold pressure)		
Mixture control (Brit.) (See Control, altitude mixture)		
Nipple, union	Union	A coupling for pipes and fittings, facilitating connection or disconnection.
Nut, spanner	Ring nut	A ring-shaped nut with notches in the outer circumference.
Oil, slushing, or slushing compound	Corrosion inhibitor	A semisolid oil or grease used as a protective coating for bright metal surfaces.
Pad	Accessory mounting face	A raised machined surface on an engine, upon which accessories may be mounted. (May include end of drive shaft.)
Palnut	Lock nut (type of)	A very thin nut used to bind another nut and prevent it from loosening.
Paraffin	Paraffin wax or paraffin	A waxy, inflammable substance produced in distilling wood, lignite, or coal.
Pin, cotter	Split pin	A split cotter, the ends of which are bent after insertion through the cotterway.
Pin, knuckle	Wrist pin or anchor pin	The pin in the bearing attachment of an articulated connecting rod to the master connecting rod.
Pin, piston	Gudgeon pin or piston pin	A round shaft used in the pin bearing connection between the piston and connecting rod.
Piston pin (See Pin, piston)		
Plugs, spark	Sparking plug	A unit holding the positive and negative electrodes which form the spark gap in a combustion chamber.

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American	*British Equivalent*	*Definition*
Pressure, manifold	Boost pressure or boost	The pressure in the induction system at a point standardized for each type of engine. "Manifold pressure," on American installations, is usually measured in inches mercury absolute; on British installations, however, it is known as "boost pressure," and is measured in pounds per square inch above or below standard sea-level atmospheric pressure.
(to) Prime	(to) Prime or dope	To operate a pump which squirts raw gasoline into the intake passages or cylinders to facilitate starting.
Propeller	Airscrew (obsolete), propellor, or propeller	A power-driven bladed screw designed to produce thrust by its rotation in the air.
Propeller, adjustable	Adjustable-pitch airscrew (obsolete) or adjustable-pitch propellor	A propeller whose blades are so attached to the hub that the pitch may be changed while the propeller is at rest.
Propeller, controllable	Controllable-pitch airscrew (obsolete), variable-pitch airscrew (obsolete), controllable-pitch propellor, or variable pitch propellor	A propeller whose blades are so mounted that the pitch may be changed while the propeller is rotating.
Rated engine speed (See Speed, rated engine)		
Regulator, manifold pressure	Boost control unit or automatic boost control unit	An automatic device which so regulates the throttle that a predetermined boost pressure is not exceeded.
Right	Starboard	Situated to the right, looking in the direction of motion of an aircraft.
Ring, exhaust collector, or exhaust manifold	Exhaust ring or exhaust manifold	A circular duct into which exhaust gases from the cylinders of a radial engine are discharged.
Ring, lock, or snap ring	Circlip	A spring-wire ring, usually to retain a spanner nut or piston pin in place.
Rod, articulated	Auxiliary connecting rod	A connecting rod used in a radial engine in conjunction with a master connecting rod.
Roller bearing (See Bearing, ball)		
Round-head screw (See Screw, round-head)		
Run, green	Running-in	Operation of a newly built mechanism long enough and at the proper speeds to control the first wear that occurs, so that subsequent service operation may be satisfactory.
Safety wire (Brit.) (See Wire, lock)		
Screen (ignition) (See Shield)		

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American	*British Equivalent*	*Definition*
Screen (oil) (See Filter)		
Screw, cap	Set screw	A threaded bolt used generally without a nut to secure a cap or cover.
Screw, fillister	Cheese-headed screws	A screw whose head is cylindrical and slotted, with a convex or flat top.
Screw, flat-head	Countersunk-head screw	A screw with a flat head, which is bevelled on the lower side so as to fit into a countersink.
Screw, round-head	Round-head screw or cup-headed screw	A screw with a hemispherical head.
Setscrew or headless set-screw	Grub screw	A headless machine screw, screwed through one part tightly upon another part to prevent relative movement.
Slushing compound (See Oil, slushing)		
Socket or plughole	Socket	A fixed female fitting for making electrical connections by the insertion of a plug.
Socket wrench (See Wrench, socket)		
Spanner nut (See Nut, spanner)		
Spanner wrench (See Wrench, box-end)		
Spark plug (See Plug, spark)		
Speed, calibrated air	Indicated air-speed (A.S.I.)	The reading of the air-speed indicator, corrected for instrumental and installation errors.
Speed, critical	Stalling speed	The lowest speed of an aircraft at which control can be maintained.
Speed, indicated air (IAS)	Air-speed-indicator reading	The reading of the air-speed indicator.
Speed, minimum	Minimum flying speed	The minimum air-speed at which an airplane can be maintained in level flight.
Speed, rated engine	Maximum rpm for continuous cruising	The highest speed of an engine at which its reliability has been determined for continuous performance.
Stack	Pipe (single)	A single pipe, usually an exhaust pipe, from an engine cylinder to the atmosphere or to a manifold.
Tachometer	Engine speed indicator (E.S.I.), tachometer, revolution indicator, or rev. counter	An instrument which measures revolutions per minute of an airplane engine.
Tag	Label or tag	A slip of paper, cloth, or metal affixed to anything and indicating the contents, ownership, destination, rating, or designation.

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American	*British Equivalent*	*Definition*
Test after overhaul (Brit.) (See Test, block)		
Test, block	Test after overhaul	The test given an airplane engine generally after overhaul but before installation in the airplane.
Test Club (See Club, test)		
Thrust, propeller	Airscrew thrust (obsolete), or propellor thrust	The component parallel to the propeller axis of the total air force on the propeller. Its symbol is T.
Valve	Cock or valve	Any device by which the flow of liquid or gas may be started, stopped, or regulated.
Valve, check	Non-return valve or check valve	A valve which permits flow in one direction but prevents a return flow.
Vent	Vent-pipe	A pipe leading from the air space in a fuel, oil, or coolant tank to the atmosphere.
Vise or Vice	Vice	A device having two jaws closed by a screw to hold work.
Washer (Brit.) (See Gasket)		
Washer, lock	Spring washer	An open, spiral, spring-tempered steel washer for preventing the loosening of nuts.
Wire, lock	Safety wire	A wire used to secure a small part so that it cannot loosen.
Wrench	Spanner or wrench	An instrument for exerting a twisting load, as in turning bolts or nuts.
Wrench, box-end, closed spanner wrench or spanner wrench	Ring spanner	Any wrench with a ring-shaped end into which the nut fits.
Wrench, monkey	Screw-spanner	A straight-handle wrench having one fixed jaw set at right angles to the handle and one adjustable jaw.
Wrench, socket	Box spanner	A section of hexagonal tubing which fits over a nut and which is turned by means of a bar passed through its upper end.

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